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May 1959

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space / aeronautics

RESEARCH • DESIGN • DEVELOPMENT

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HILLER X-18
(see "What Price VTOL?")



Avco/Nashville experience And Convair 600

The new Convair 600 marks a "first" in aviation—it is the first jet transport to employ the "area rule" concept for increased speed at critical Mach numbers.

For design and production of many of its components—the horizontal and vertical stabilizers, and important parts of the wing leading and trailing edges . . . Convair once again has selected Avco's Nashville Division, which already is producing important components for the Convair 880 jet liner. Both Convair jets are planned to give years of dependable airline service.

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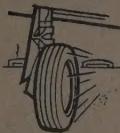
HERE'S SKID PROTECTION

Sure and simple



Basic units of the Goodyear Anti-Skid System—specified for the Convair B-58 and Republic F-105. Installed on a 2-wheel fighter, the system weighs under 6 lbs.

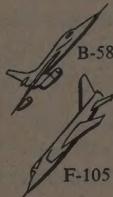
1 FIRST, CONSIDER THIS—At today's high landing speeds, a skidding tire can "flat spot" in two seconds. Several seconds later, it will blow out—endangering plane and personnel, requiring costly down time that can wreck flight schedules. The pilot—sitting ahead of wheels—can be unaware of danger until too late.



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Anti-Skid System automatically releases brake pressure until skid danger has passed. Brake is reapplied automatically.

Pilot Modulated Anti-Skid System is combination of other two. Provides automatic skid protection yet allows pilot control if desired.



4 FOR DETAILED INFORMATION on these 3 miniaturized, lightweight skid control systems—and specific facts that will help you decide which system is best for you—write Goodyear, Aviation Products Division, Akron 16, Ohio, or Los Angeles 54, California.



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space/aeronautics

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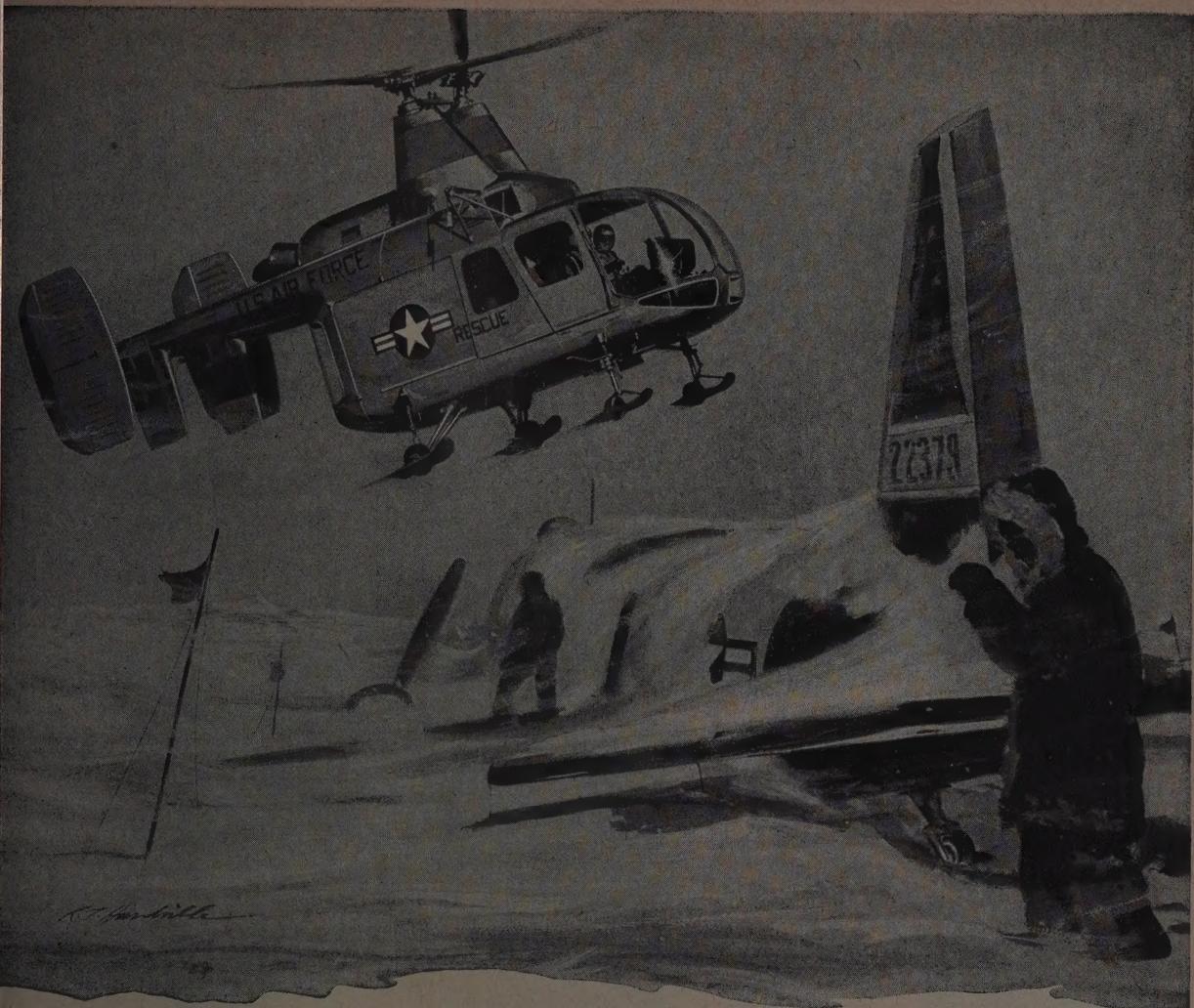
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SPACE/AERONAUTICS



From an original painting for CECO by R. T. Handville

KAMAN'S H-43B HUSKIE is powered by a Lycoming T-53 gas turbine with complete, single-package *fuel control and pumping system* engineered and precision-produced by Chandler Evans.

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Chandler Evans *pioneered* single-package design of formerly separate fuel system components and today enjoys a position of leadership in the field of small engine fuel control and pumping systems.

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from Magnet Charger

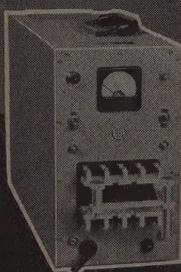
HEADQUARTERS

MODEL 1500

with
Dual Ranges
to 40,000
Ampere-Turns

3

VERSATILE
MODELS



MODEL 107A

Designed for production, research and instrument repair work, the Model 1500 will magnetize the new cobalt platinum and barium ferrite materials as well as all the Alnicos. It will saturate large switchboard meter assemblies and all panel type instruments and uses most existing adapters designed for the Model 107A. Wire-wound fixtures are plugged into front panel through a safety interlock system providing maximum operator protection. Operates from 115-volt, 60 cps line. Size 11 x 20 x 15; weight 125 lbs. Price \$945.

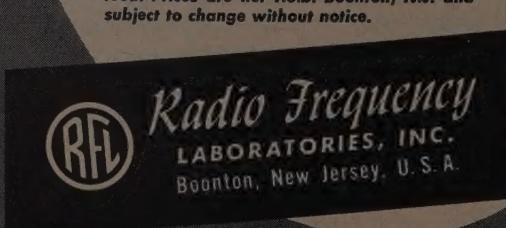
A basic condenser discharge unit for most medium size magnets, the Model 107A provides ranges of 12,000 and 24,000 ampere-turns. It is capable of saturating most instrument magnets, including the new core type mechanisms, using adapters or wire-wound fixtures. Designed for continuous duty. Operates from 115-volt, 60-cycle line. Price \$530.

A high powered magnetizer (up to 200,000 ampere-turns) capable of charging large Alnico and ceramic magnets of various shapes or pole configurations. Adapters for multi-pole rotors, rod, bar, ring and other shapes are available. Designed for continuous production use. Size 30" x 33" x 38"; weight 235 lbs. with 200-uf unit. Price of basic unit is less than \$2100.

Performance of all models is rigidly guaranteed. Prices are net f.o.b. Boonton, N.J. and subject to change without notice.



MODEL
942



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BIGGEST U.S. VTOL-STOL design yet is Hiller's 33,000-lb X-18 tilt-wing test vehicle, built for the Air Force. Its reasons for designing such a heavy experimental plane, Hiller points out, where (1) that the X-18's size is just right for the intermediate range, in which VTOL-STOL characteristics are most badly needed, (2) past experience showed that smaller tilt-wing test models leave many technical and operational questions unanswered, and (3) the X-18 largely could be put together from existing hardware—the fuselage comes from a Chase C-123 and the two T40 Allison turboprops from earlier Navy VTOL programs.

Each of the X-18's T40s actually consists of two power sections coupled to a common reduction gear box and puts out 5535 eshp. A fifth engine, a 3400-lb thrust Westinghouse J34 jet, is installed in the aft fuselage for pitch control in hovering and transitional flight. Roll during these flight regimes is controlled by differential thrust of the two turboprop engines and yaw by the ailerons actuated in the down wash of the props. (See also "What Price VTOL?", p. 46.)

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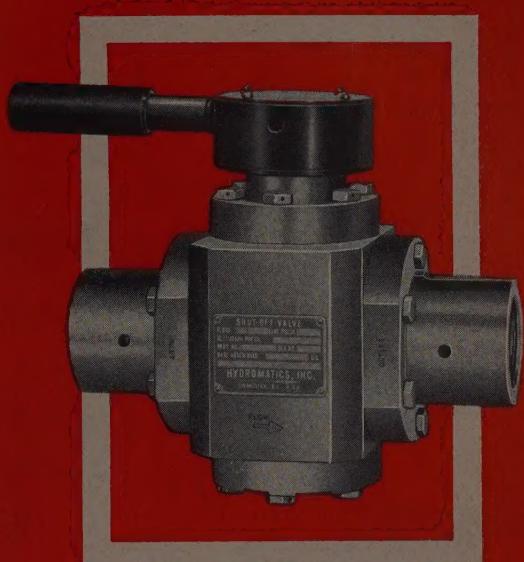
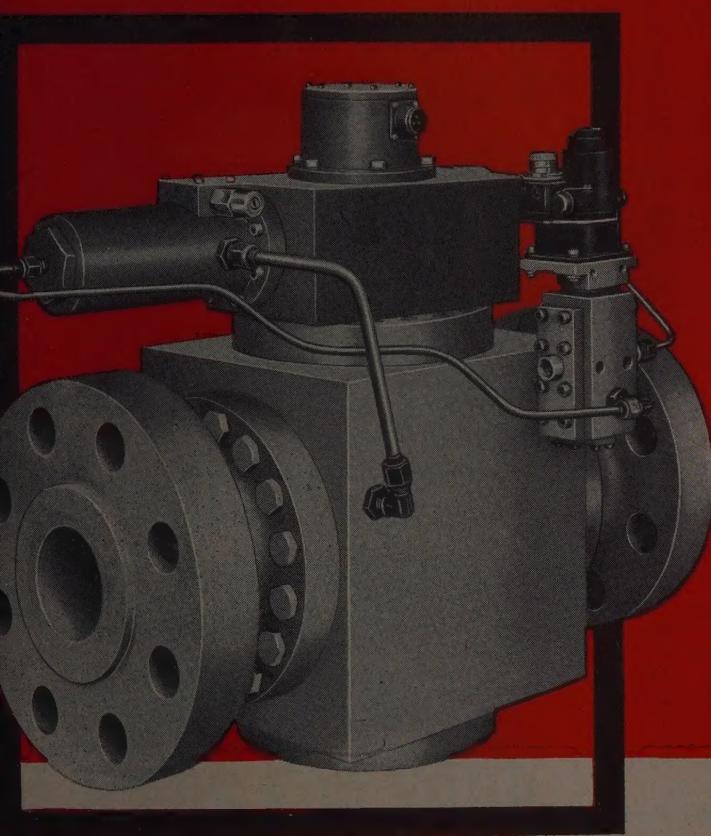
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base installations with off-the-shelf hardware to such special uses as catapult launchers, arresting gear, and emergency shut-down systems.

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May 1959

volume 31, number 5

space/aeronautics

RESEARCH • DESIGN • DEVELOPMENT

aircraft / missiles / spacecraft

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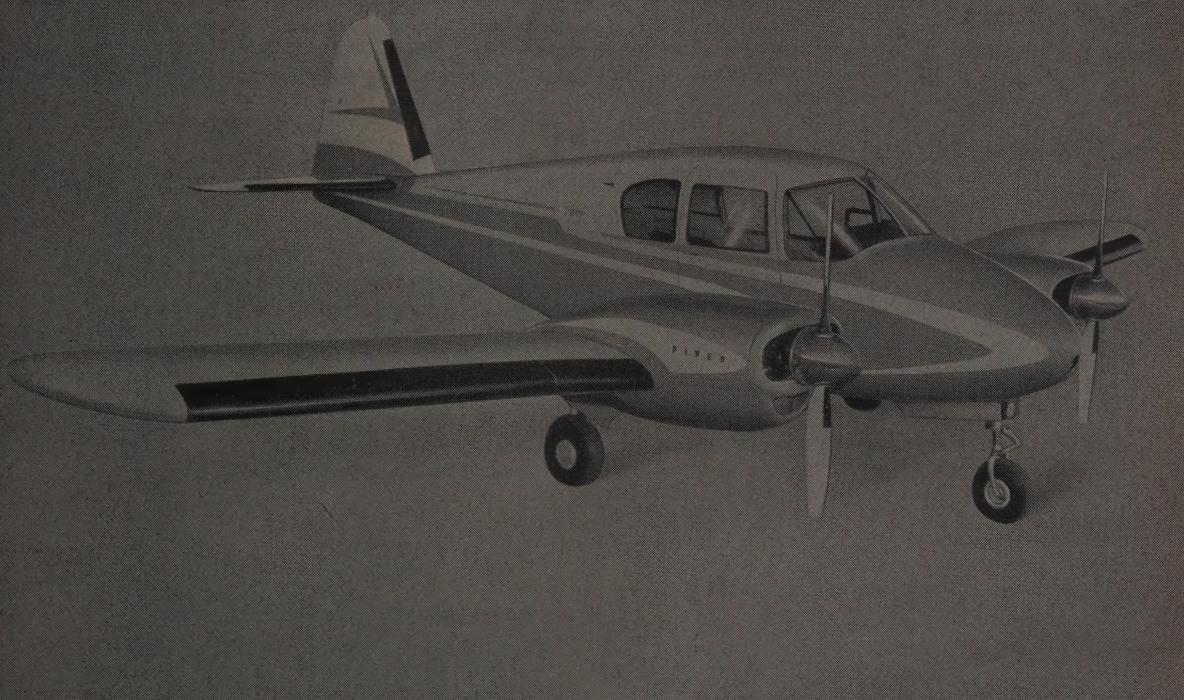
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B.F. Goodrich



ANNOUNCING: NEW LIGHTWEIGHT B.F. GOODRICH DE-ICERS FOR YOUR PIPER APACHE

B.F. Goodrich Aviation Products announces a brand new, lightweight De-Icer system for the Piper Apache!

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A complete kit, fully FAA-approved, is now available for the Piper Apache. Contact your local B.F. Goodrich Aviation Products distributor and see how easily you can have your own Piper Apache equipped with this low cost ice protection. Or write: *B.F. Goodrich Aviation Products, a division of The B.F. Goodrich Company, Dept. SA-59, Akron, Ohio.*

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in this issue

Here's a quick rundown of the technical information offered in the articles in this issue. You can also use these article abstracts to build up your own permanent record for reference in the future—just clip them, paste them up on standard three-by-five cards, and file them.

Space/Aero Engineering
Dynamics

Astia code: 2-1; 25-5
Your code:

Time dilation in space travel

Review of problems raised by time dilation effects, as postulated by relativity theory, on interstellar flight at extremely high speeds. Recent scientific arguments for and against "reality" of time dilation are discussed. Einstein's derivation of time dilation and "rod shrinkage" from Lorentz' theorems is explained.

by Kurt R. Stehling, Contributing Technical Editor
space/aeronautics 31/5 (May '59)

p. 43

Space/Aero Engineering
Systems Engineering

Astia code: 1-2; 9; 27-2
Your code:

What price VTOL?

Discussion of feasibility of future VTOL transports. Comparisons are made between unloaded-rotor, propeller-powered, and jet-powered VTOL craft and conventional transports.

by Marion O. McKinney, Jr., NASA
space/aeronautics 31/5 (May '59)

p. 46

Space/Aero Engineering
Production Engineering,
Propulsion

Astia code: 12-4; 26-1; 27-3
Your code:

Deep drawing for high strength solid rocket casing

Size and strength limitations of suitable hot work tool steels. Mechanical properties are given for 10 materials. Techniques are described for determining drawability and formability for new casing design, using scale models of final casing, as are final design and development tips and fabrication processes.

by Larry Shiller, Norris-Thermador
space/aeronautics 31/5 (May '59)

p. 49

Space/Aeronautics
System Engineering, Dynamics,
Structures, Accessory Systems

Astia code: 1-2; 3; 7-5; 27-2
Your code:

Overall capability is key to N-156F design

Design study of new lightweight fighter developed by Northrop. Basic concept of the project and aerodynamic, structure, and maintenance design features are discussed. Arrangement of accessories is described in detail.

by Irwin Stambler, Associate Editor
space/aeronautics 31/5 (May '59)

p. 52

Space/Aero Engineering
Systems Engineering, Dynamics
Structures, Propulsion,
Accessory Systems

Astia code: 1-2; 27-2
Your code:

Avro Arrow: New frontiers of fighter design (Design Progress)

Partial cutaway isometric of CF-105 with details of area rule modification of original design, engine intake ducting and boundary layer control, engine cooling, inner and outer wing structure, and flight control system. Describes materials used and points out unique design features.

by Victor DeBiasi, Associate Editor
space/aeronautics 31/5 (May '59)

p. 57

Space/Aero Engineering
Propulsion, Systems Engineering

Astia code: 1-2; 27-2
Your code:

Turbo-ramjets best for Mach 2-3?

Performance and design details of supersonic Nord Griffon II, powered by subsonic turbojet mounted centrally in a ramjet duct. Theory and advantages of this turbo-ramjet combination are discussed, and thrust and thrust coefficient curves are shown.

by Denis Desoutter, Foreign Corresponding Editor
space/aeronautics 31/5 (May '59)

p. 61

Space/Aero Engineering
Production Engineering

Astia code: 26-1
Your code:

Faster forming of complex parts with spin forging

Discussion of spin forging which combines spinning and roll forging into a single operation and can be used for previously impossible fabrication of structural and powerplant components in one piece. Characteristics and performance of first operational machine are described in detail.

by Randolph Hawthorne, Editor
space/aeronautics 31/5 (May '59)

p. 69

Space/Aero Engineering
Accessory Systems

Astia code: 13-1
Your code:

External wire fins for compact missile heat exchangers

Discussion of new types of extended-surface heat exchangers that can provide marked weight and size reductions. Coil-wire and punched-disk fin arrangements are described as well as the need for careful quality control to produce leak-free units.

by Irwin Stambler, Associate Editor
space/aeronautics 31/5 (May '59)

p. 77

To make filing easier, each abstract is coded according to the Astia Distribution Guide. Copies of this guide are available from Armed Services Technical Information Agency, Arlington Hall Sta., Arlington 12, Va. There is also room on the abstracts for you to insert your own key if you use a special coding system.

Space/Aero Engineering
Materials, Structures,
Production Engineering

Astia code: 1-3; 14-1
Your code:

New silicone rubbers meet tough DC-8 specs

Application of new room-temperature vulcanizing, GE SE-555 high strength, and GE SE-701 silicone rubber compounds in Douglas DC-8. New design concepts for ducting and production methods for the compounds are discussed.

by R. T. Daily & R. W. Scholler, General Electric & Semco Research, resp.

space/aeronautics 31/5 (May '59)

p. 85

Space/Aero Engineering
Production Engineering

Astia code: 7-3; 8-2
Your code:

Automated Wire-Wrap cuts production costs in half

Physical characteristics of Wire-Wrapped electric wiring connections for airborne electronic assemblies. Shows mechanical steps in making the connections. Includes design tips on optimum ratio of terminal thickness to wire gage and figures on stripping forces and contact pressures.

by Victor DeBiasi, Associate Editor

space/aeronautics 31/5 (May '59)

p. 95

Space/Aero Engineering
Testing, Dynamics

Astia code: 1-2; 30-6
Your code:

Cheap wind tunnel models from plastic kits

Report on USAF Air University study of using commercially available plastic model kits for wind tunnel work. Model preparation for evaluation is discussed, and some of the results are described.

by Irwin Stambler, Associate Editor

space/aeronautics 31/5 (May '59)

p. 99

Space/Aero Engineering
Production Engineering, Testing,
Materials

Astia code: 17-4; 26-2; 30-3
Your code:

New tests and materials for high temperature fasteners

State of the art in high temperature fasteners. The need for more accurate test equipment and fixture is discussed, and an improved shear fixture is described. Trends in high performance fastener materials are covered.

by Irwin Stambler, Associate Editor

space/aeronautics 31/5 (May '59)

p. 107

Space/Aero Electronics

Astia code: 8-2, 3

Your code:

Researchers explore exotic gyros

Review of theory and basic operation of gyros using inherent angular momenta of electrons and protons. Relevant theories of atomic and nuclear physics are explained, and the workings of the two basic particle gyro types—relying on precession and rigidity in space, respectively—are diagramed and analyzed.

by James Holahan, Electronics Editor

space/aeronautics 31/5 (May '59)

p. 130

Space/Aero Electronics

Astia code: 8-3; 12-2; 22-7

Your code:

Azusa predicts ballistic missile impact points

Analysis of requirements for an impact-predicting tracking system for ballistic missile tests and description of Convair Azusa tracker-computer-display system used at Cape Canaveral. Characteristics are shown by prediction results for three hypothetical missiles. Three dispersion tables are included.

by S. L. Ackerman & R. C. Weaver, Convair-Astronautics

space/aeronautics 31/5 (May '59)

p. 134

Space/Aero Electronics
Pages from an Engineer's Notebook

Astia code: 8-4

Your code:

SF₆ waveguide dielectric breakdown curves

Breakdown curves for sulphur hexafluoride used as waveguide dielectric for high power radar at S- and L-bands and related findings of a study by Airborne Instruments Lab. Minimum breakdown ratios are tabulated.

space/aeronautics 31/5 (May '59)

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Space/Aero Electronics

Astia code: 5-2; 8-2

Your code:

ARC-62 forecasts

Mach 3+ aero electronics (Design Digest)

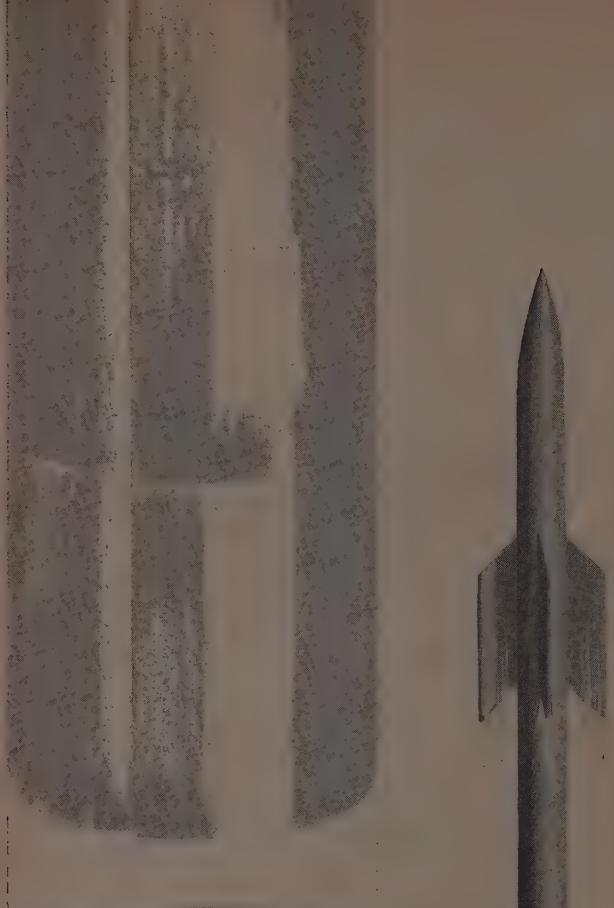
Analysis of the AN/ARC-62 UHF communications set. Details of the advanced design techniques used are presented in functional diagrams, covers-off photos of typical modules, and complete design and performance specs. The inherent translator functions are outlined and practical details are given of "uniform design criteria."

by Bernard Kovit, Associate Electronics Editor

space/aeronautics 31/5 (May '59)

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continued on page 13



Do you know about
Gask-O-Seals?

THIS Gask-O-Seal EXCEEDS HERMETIC SPECS!

Gask-O-Seals often equal or exceed specification for hermetic sealing. The one shown here, for instance, has eight sealing points and is on one of our newest missiles. The leakage rate is less than the original hermetic seal specification called for which is about as perfect as any seal can be.

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in this issue

continued from page 11



Space/Aero Electronics

Astia code: 8-2

Your code:

One-ounce servo amp puts out two watts

Brief design analysis of subminiaturized Ketay amplifier for use from -55 to +100 deg. C. Construction and packaging features are highlighted, circuit diagram is shown, and characteristics are listed.

by James Holahan, Electronics Editor
space/aeronautics 31/5 (May '59)

p. 145

coming next month

IN TIME for the biennial International Aviation "Salon" in Paris, France, SPACE/AERONAUTICS will publish its special report on "European Aviation Progress." In a series of three articles, it will bring you up to date on the overall status of the aircraft/missile industries of Europe and report in detail on engineering advances. Special coverage will be given to the latest electronics developments.

In addition, there will be a brief company "profiles" based on an extensive survey of Europe's aircraft missile firms. These capsule descriptions will give precise data on capabilities and facilities.

Also included in the special report will be product and literature sections devoted to the achievements of European companies.

MORE LIKELY than not, our early space stations will have to be assembled in space—we just won't have the propulsion to shoot them up in one piece. How such an assembly operation hundreds of miles above the earth might be worked will be examined in a detailed design study.

DETAILED design features of one of our most advanced ballistic missiles will be described in next month's Design Progress.

coming soon

THE ENGINEERING PROBLEMS of manned exploration of the fringes of space will be taken up in a detailed analysis of one of the highly advanced vehicles now being tested.

Space/Aero Electronics

Astia code: 8-2

Your code:

Slidewire-tape pot boasts infinite resolution

Design details of slidewire tape potentiometer. Precise tape calibration technique is described. Application and advantages of device in precision temperature and pressure measurement are outlined. Examples are given of instruments built around the resistive slidewire element.

by Bernard Kovit, Associate Electronics Editor
space/aeronautics 31/5 (May '59)

p. 175

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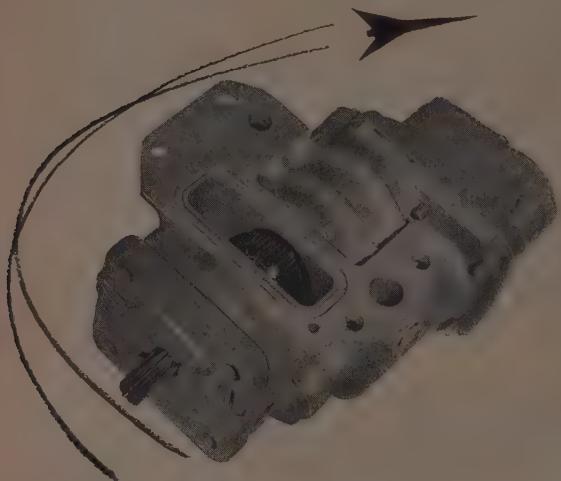
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keeping in touch . . .

GENERAL POWER, testifying before the House Appropriations Committee, spoke of the "fantastic compression of time" that has taken place in military technology. This time compression has occurred in more places than the SAC commander perhaps had in mind. Certainly, it is evident throughout the space/aero industry.

But it is more than a matter of time. It is a matter of communications. This is one of the most important factors in the engineering profession. Because of the rapid and revolutionary changes which have taken place in a few years' time, two somewhat contradictory pressures have been exerted on space/aero technical people: One, to specialize; the other, to keep in close touch with what is going on in related technologies with which one's own is integrated.

BUT IT doesn't stop there. Ideas can come from anywhere. Artificial restraints, such as the "need to know" concept of military projects, have a stultifying effect.

Technical publications, such as ours have felt the impact of the technological revolution along with the industry they serve. At one time we were satisfied to know that we communicated to "engineers", to "scientists", and to "technical managements". From personal contact, we know you are deep in various technical areas, in special parts of these areas, and in details of those specialties.

But with the assault on space, a trend is developing to recombine all branches of the art. At the same time, different emphasis is being placed on various disciplines. There is a realignment of company structures. And there is a development of new specialties.

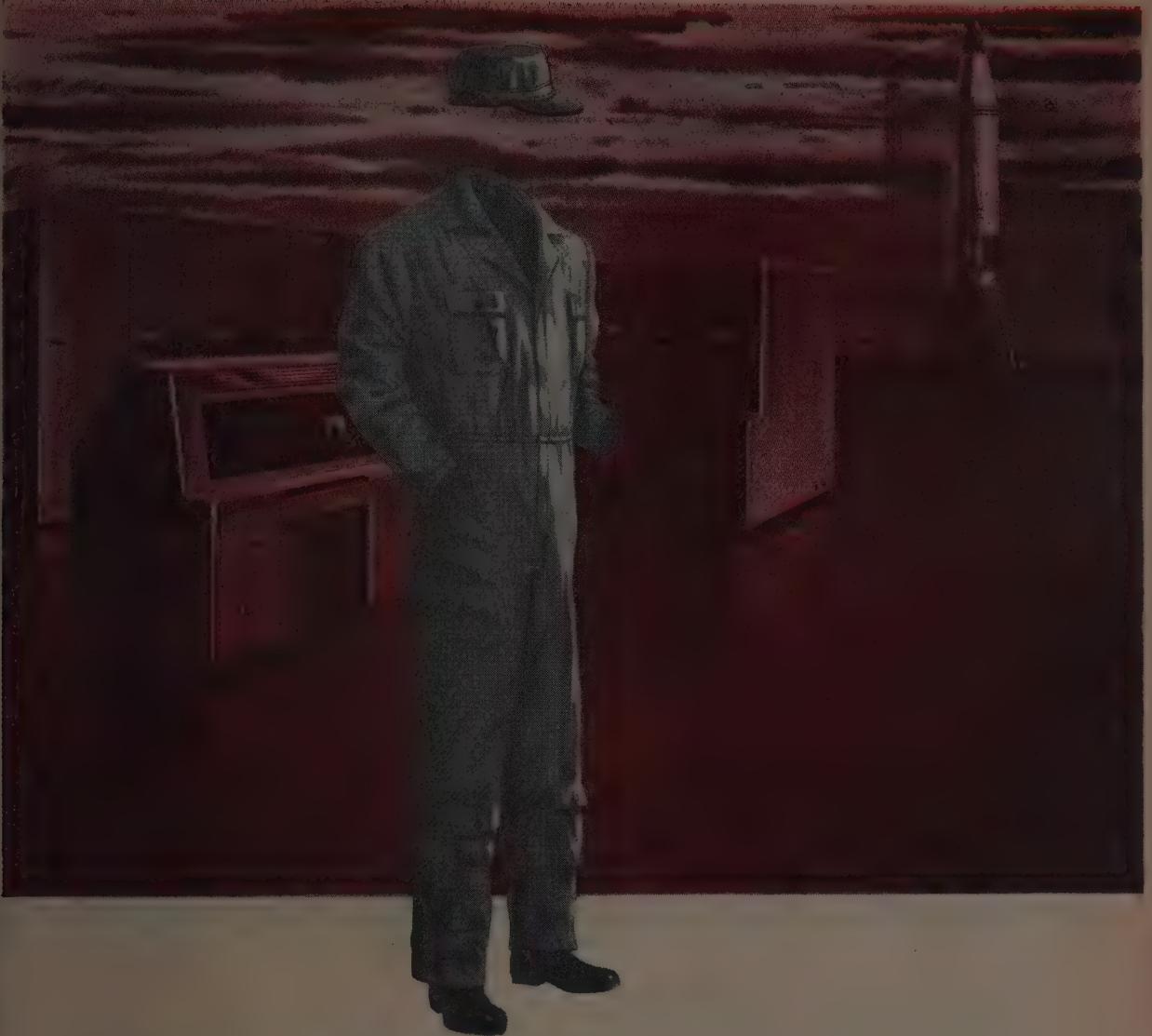
FOR INSTANCE, electronics engineers on advanced systems are finding they must know more about metallurgy. This poses semantic problems, for the two disciplines have developed separately and find it hard to communicate with each other. Yet, communicate they must.

The editors of SPACE/AERONAUTICS, themselves engineers, continually try to press forward the boundaries of technical communications. The prime purpose is to provide that information which is needed on the job, directly or indirectly, now or in the near future.

Questions uppermost in our minds are: What technical specialties do you use most in your work? Are specialized articles wanted in areas which are a subordinate part of your job assignments? Do you want specialized and detailed articles in your own specialty? How useful do you find our special reports, such as Ground Support Equipment, Space Flight, etc.?

This is a dynamic industry. No one in it or serving it can stand still, content with past achievements.

William G. Maass
Publisher



suit-ability

FROM PHILOSOPHY — TO FEASIBILITY STUDY — TO DESIGN AND PRODUCTION

GENERAL ELECTRIC'S GROUND-BASED

GUIDANCE SYSTEM FOR THE ATLAS MISSILE

REQUIRED A COMPLETE MAINTENANCE

TRAINING METHOD FOR MILITARY

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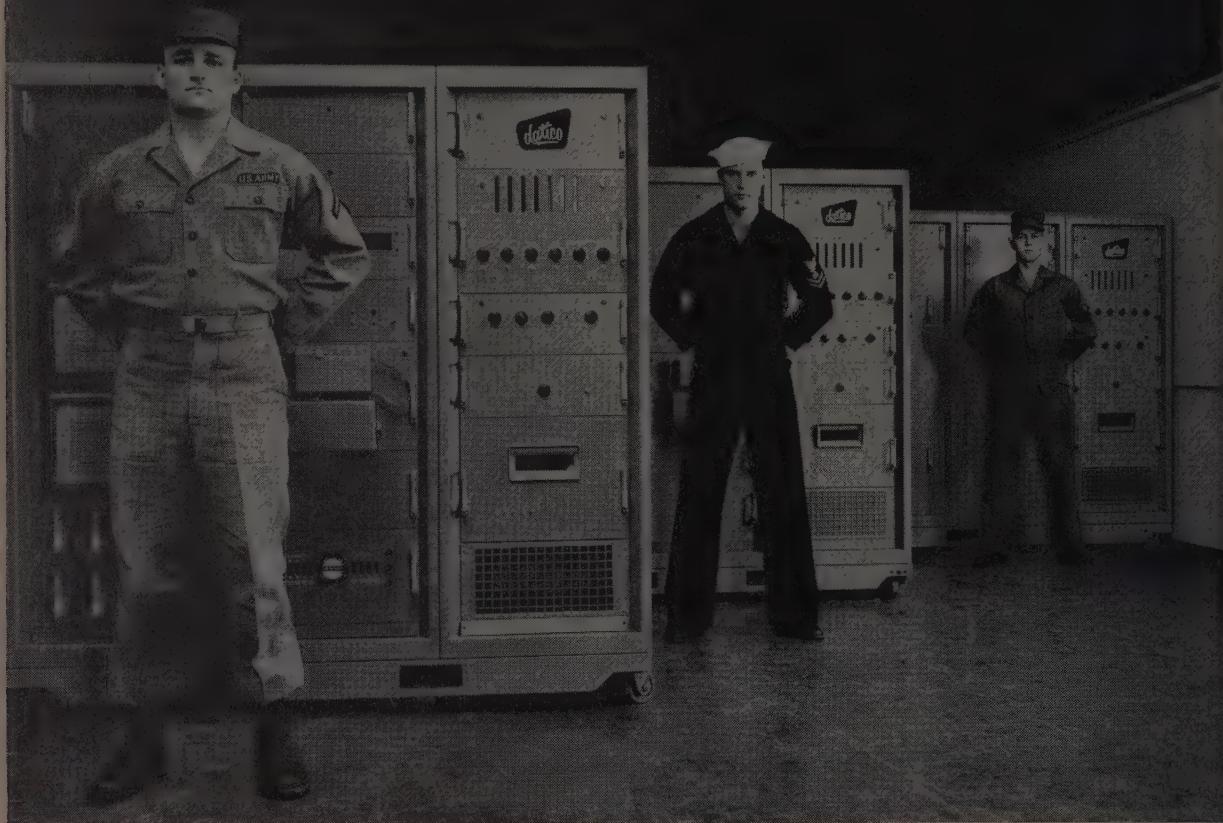
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line checkout application to U.H.F. equipment. Today's Universal Datico is available off-the-shelf: Federal Stock Catalog Number 6625-650-7542. It can be readily packaged for maximum mobility, and is applicable for use at launching sites, maintenance areas, depots, and assembly-line checkout stations.

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editorial

The President's judgment

PRESIDENT EISENHOWER says he is better able to judge our defense needs than any Pentagon expert. Certainly, as President he has *access* to all information on which to form judgments and make decisions.

But there is serious doubt about the quality of information *made available* to him. Early this year, an industrial manager in the aircraft nuclear propulsion program wrote his fears to the President: "I recognize that your responses [on the usefulness of ANP planes] were based upon the best information available to you. I am only concerned as to the quality of that information and, speaking frankly, it is my opinion that you have been on the receiving end of some sloppy staff work, which may be setting some sort of historical records . . . "

The point he makes obviously is grave. Judgments and decisions can be no better than the information on which they are based. Mr. Eisenhower believes his 1960 defense budget is adequate. On what does he base his opinion? With Berlin as a backdrop, here is what his field commanders testified:

"With my mission requiring me to be combat-capable all the time," U.S. Army (Europe) commander Gen. Hodes said, "I need \$60 million more." This is not "frill" money. Gen. Hodes must absorb \$24 million in added missions and increased costs. Moreover, unless he replenishes a \$36-million deficiency in stocks, he will not be combat-ready as the Berlin crisis comes to a head.

AVAILABLE BRIEFINGS show the Soviet army has mobile missiles varying from 10 to 1100 miles in range. U.S. Army missile ranges are limited to 15-175 miles. Unless the Army's mission to be combat-ready all the time is a farce, it would seem its missile strength is woefully inadequate.

Yet, the President says we have enough. He believes in the "minimum" deterrent power. But what is the "minimum" deterrent?

SAC commander Gen. Thomas Power says: "Nobody knows what the minimum deterrent is." He adds: "If anybody tells you they (*sic*) know what the minimum deterrent is, tell them for me that they are liars. The closest to one man who would know . . . would be Khrushchev, and frankly I don't think he knows from one week to another."

"I feel strongly," Gen. Power declared, "that we must get on with this airborne alert to carry us over this period. I think you are just risking the whole country. That is how important I feel it is."

Yet the President says we don't need the airborne alert.

Does Mr. Eisenhower get all pertinent information? There is grave doubt he does.

Randolph Hawthorne, Editor

How versatile **Cronaflex** streamlines production

Union Switch & Signal Division of Westinghouse Air Brake Company, Swissvale, Pennsylvania, has discovered that Du Pont CRONAFLEX saves time and expense in several different ways in the design and manufacture of automatic control equipment for railroads and pipelines.

First of all, diagrams of control systems do not have to be completely redrawn if they contain the basic elements. Instead, the basic data is drawn once and then photographically reproduced on CRONAFLEX as many times as necessary, and the variable additions added to meet the specific requirement.

When preparing wiring diagrams for complex systems, Union Switch & Signal starts with reproducible template prints that contain basic parts of a composite control system. On these the designer adds the required wiring information. Then he cuts out the unused elements and reproduces the selectively cut print on CRONAFLEX, which serves as the final tracing.

CRONAFLEX is also used to make accurate, legible reproduced tracings of valuable originals which due to age and use have developed poor contrast causing illegible reproductions.

In addition, CRONAFLEX helps this company put an accurate picture directly on metal or plastic parts, eliminating expensive layout time for machining operations. The material is spray-coated with a photosensitive emulsion, placed in contact with the layout drawing on CRONAFLEX, and exposed in a vacuum frame. After development the piece is engraved, punched or machined for use as part of a product or used as a template in punching operations, directly from the picture on the material. This is feasible because CRONAR* base of CRONAFLEX resists shrinking and stretching caused by changes in temperature and humidity.

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Unwanted elements of a drawing are cut from the composite print before reproducing on CRONAFLEX. This saves time spent in laborious eradicating.



CRONAFLEX is also used to make metal or plastic templates. Material is spray-coated with emulsion, then CRONAFLEX drawing is printed right on the surface.

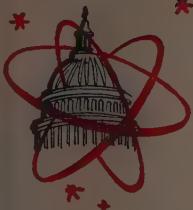


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washington briefing

by A. N. Wecksler, Washington Bureau Chief

How does Congress decide on defense?

MEMBERS of the Joint Chiefs of Staff and other high military brass have been trooping before many committees of Congress to testify for a military budget about which they have many reservations.

Once they appear before Congress, these spokesmen take the position that the military budget proposed by the President represents satisfactory support and adequate defense.

On the other hand, the members of Congress feel it their function to get at the root of things, to find whether by more effort or more dollars we might improve our military position. In the Congress, there is general impatience with the attitude that we do it the cheap way.

There is a feeling among members of Congress that information is being kept not only from the public but from them as well. Last year they felt so strongly that the Administration was not pushing hard enough at the new barriers of space and ballistics exploration that they appropriated a billion dollars more for defense than was sought by the President. Congress wanted this money to go for more copies of the Atlas and the Titan, and for quickening of development, on the Minuteman and Polaris.

The Administration spent only a small fraction of the extra money, but this year a similar performance is likely. The President's request for \$40.9 billion for defense will be up-

ped in Congress by at least half a billion dollars—again the result of a feeling that there isn't enough urgency in our defense buildup.

Part of the problem lies in the fact that few members of the U.S. Congress have a technical background. The legislators are mostly lawyers and businessmen; in the total membership of the Senate and the House, only an occasional engineer or chemist shows up.

In contrast, among the 1269 delegates to the 21st Congress of the Communist Party, 287 were engineers, and a portion of the remainder were scientists. There is no direct comparison between functions of the Congress of the Communist Party and our own Congress, but the contrast does serve to highlight the emergence of science and engineering in Soviet politics.

With scientific competence almost non-existent among the members of our Congress, the Congress has to rely on the testimony of spokesmen for the armed services, and the statements of the Joint Chiefs of Staff. In addition, there has been some buildup of technically qualified staff members on the various Congressional committees which have an interest in ballistics and space.

Here again, the capacity is built up to ask questions. There is little or no competence at the Congressional committee level to make independent judgments.

How then does the defense spending process break away from the straight and narrow path laid out by the Administration?

Occasionally there is the military maverick who is willing to sacrifice his career, and cry out publicly against the decisions reached in the Administration budget.

Then there are the civilian organizations that are affiliated with a branch of the military—the Navy League, Air Force Association, and the Association of the U.S. Army. These groups have close contacts and continued personal ties with important military figures in the services for which they speak. If a service gets severely pinched, its civilian counterpart will put strong pressures on Congress to make an adjustment.

Trade groups have an influence—with the Aircraft Industries Association acting for air power and space, and the National Security Industrial Association constantly pressing for greater firepower.

Private reports have been effective in influencing Congress in its policy toward appropriations. The Rockefeller Study pointed up the fact that we could afford to devote more of our gross national product to defense—while the Gaither Report made it clear that for the long pull, we were in trouble in pitting our strength against the military efforts of the Soviets.



READY

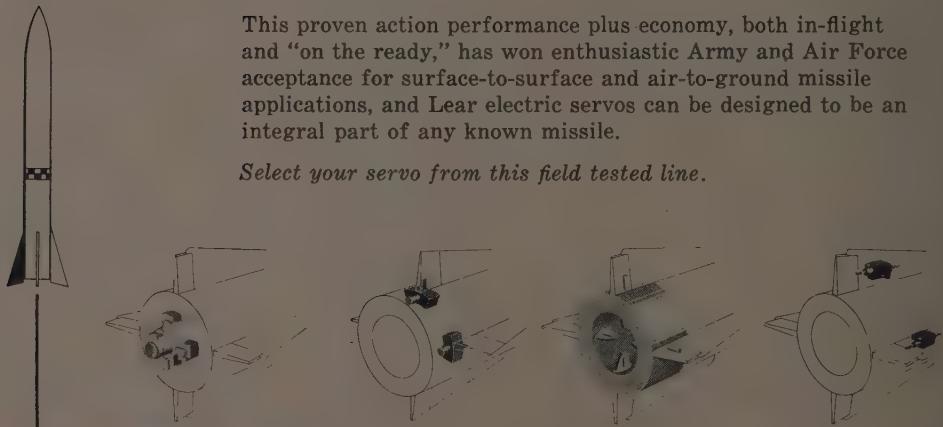
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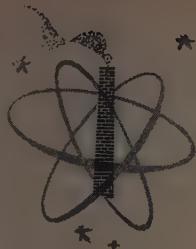
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SPACE/AERONAUTICS



industry viewpoint

by Robert M. Loebelson, Associate Editor

Newcomers plead for share of space/aero business

WITH MISSILES and space vehicles taking increasing share of the Defense Department's hardware dollar each year, many traditional aircraft firms maintain they are best qualified to fulfill virtually all missile and spacecraft contracts. The newcomers to the space/aero industry naturally disagree.

T. F. Morrow, vice president of Chrysler's Defense & Special Products Group, is one who feels there is room in the business for all. The man administering Chrysler's Redstone, Jupiter, and other defense output, points out:

"I think it is every industry's job to contribute to the nation's welfare and defense programs whenever it can. Everyone seems to be in the defense business, because no one has a monopoly on anything in this country."

The Chrysler v-p cites the fact that companies producing military hardware must continually prove their qualifications: "Because we are in the ballistic missile game now doesn't give us a right to be in it 10 years from now. We have to earn it."

Aside from that, says Morrow, only a few old-line aviation firms predate his company's efforts in the ballistic field. "We aren't moving into a field in which the aviation companies were entrenched. We've been working on ballistic missiles since October 1952—at least as long as most of the aviation industry."

The Chrysler official believes that companies whose sales are primarily to the general public face a challenge that does not confront manufacturers whose products go principally to the Defense Department. "It is incumbent on commercial companies to see that every military program in which they participate is a success," he points out. "Identification with a failing Defense Department project naturally hurts future chances of getting military work. But it could hamper the sale of commercial products as well. It is for just that



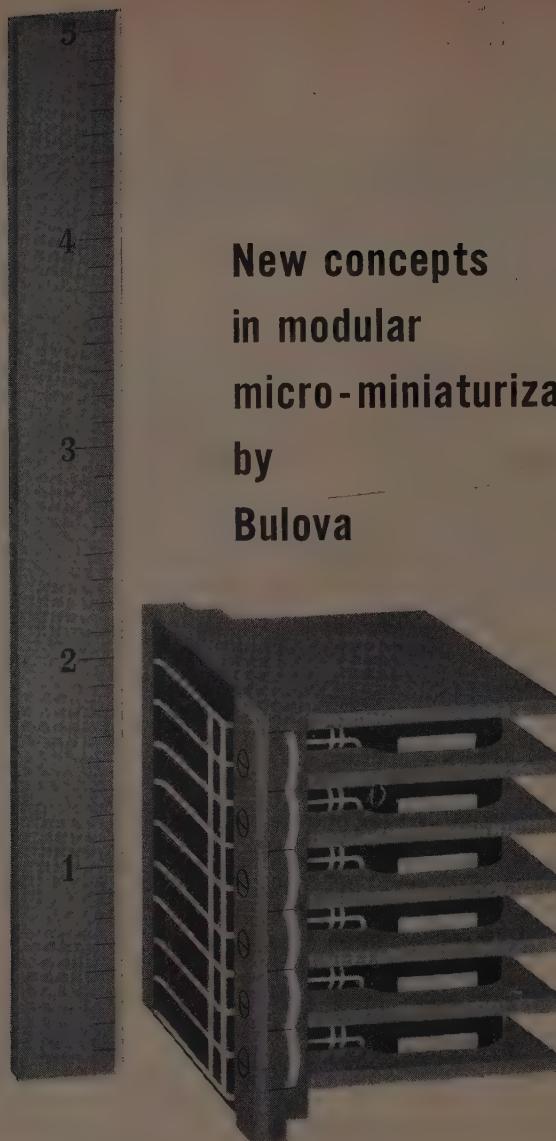
T. F. MORROW, vice president, Defense & Special Products Group, Chrysler Corp.

reason that commercial companies study all the benefits and penalties that might result before they bid for military business."

Morrow advances still another argument about the participation of automotive, electronic, rubber, and other industries in spacecraft and missile projects: "All industries contribute to the maintenance of the defense establishment in the form of taxes. Why shouldn't those same industries be allowed to participate in missile programs if the military services consider them qualified?"

He cites the analogy of the automobile business. "Many companies have tried to get into the automobile business. Some have succeeded; some have failed. It means only that competition must meet the test of survival."

Morrow says he has no desire to get into a controversy with officials of aircraft companies who maintain that newcomers should be excluded because they jeopardize the existence of traditional aircraft suppliers. But, he adds, "I recall the period after World War II when some aircraft companies were really hurting and others were reasonably well off. I don't remember that the same companies that are now complaining about intrusions argued than for the survival of aircraft companies that needed more business."



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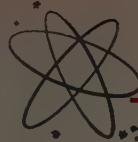
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BULOVA



technical management intelligence

USAF IS EXPECTED to make its decision on the winner of the Martin vs Boeing Dyna-Soar competition by June 30. But the goal of the current program has now been changed from an operational weapon to a test vehicle. The engine for the "aircraft" stage has been eliminated. So for the time being, the Dyna-Soar proper is strictly a glider—which will reach speeds and altitudes approaching those of the current satellites.

USAF sees the Dyna-Soar as the ultimate successor to the B-70 Mach 3 bomber. The team winning the Dyna-Soar competition will therefore be in line for lucrative contracts later on.

A DYNA-SOAR-TYPE bomber will not be in service before the late '60s at best. The first B-70 will not fly until mid-'61, meaning the bomber will not be in the AF inventory until '63 or '64. Any major reduction in lead time on the Dyna-Soar will probably reduce the number of B-70s purchased.

Scramble is on for USAF contract on air-launched ballistic missile

MORE THAN a dozen firms are trying to get the USAF contract for an air-launched ballistic missile (ALBM). Lockheed, Marquardt, and McDonnell, which have USAF contracts to study the feasibility of an ALBM, all have successfully fired their test vehicles, and AF has decided to go ahead with "Weapon System 138A" (to be launched from the B-70).

In the interim, USAF planning on air-to-surface missiles revolves around the jet-powered North American Hound Dog. In addition to the B-52G, which will fire the Hound Dog and the McDonnell Quail decoy missile, USAF and Boeing have now come up with the B-52H, which is being bought with fiscal '60 funds. The "H", which has eight P&WA J57 turbofan engines, will operate over longer ranges and at higher altitudes than earlier B-52s.

ALL JUPITER IRBMS to be used by USAF and NATO troops are being built at Chrysler's plant outside Detroit. The comparable production line at Redstone (Ala.) Arsenal is turning out only special-purpose Jupiter test vehicles.

Chrysler has not yet given up hope the Navy will buy the Jupiter for shipboard use. But Navy officials tell SPACE/AERONAUTICS the Jupiter is

out because of the problem of handling liquid propellants aboard ship.

JUPITER was originally designed as the Navy's fleet ballistic missile (FBM), but was replaced by Polaris. Navy officials concede that next fiscal year they will program an FBM for launching from surface ships, but think a modified Polaris is the answer. This Polaris may be installed on the USS Long Beach, a nuclear cruiser, next year if tests are satisfactory.

Entire missile spectrum being studied by Chrysler

CHRYSLER'S PLANT can produce far more Jupiters than are on order now. But there is little likelihood of additional orders unless more NATO nations agree to accept IRBMs.

Chrysler, whose missile experience to date has involved only ballistic types, is studying other missile types, including air-to-air, air-to-surface, surface-to-air, and target missiles. (The automobile company submitted a bid for USAF's Minuteman and reportedly finished second to Boeing).

WEST GERMANY'S licensing arrangement with Lockheed on the F-104 calls for the U.S. company to deliver 30 two-seat F-104Bs this fall. The Germans will take delivery of 66 single-seat F-104As in '61. Their own output of 200 F-10As under license will start at the end of '62.

For both the aircraft and its J79 engine, the Germans will pay four per cent royalty to both Lockheed and GE, respectively.

Storm in Japan over choice of Grumman Super Tiger

IN JAPAN, where Grumman's F11F-1F Super Tiger has been chosen for production under license, the government is being urged to re-evaluate its choice to allay public suspicions. The debate in the Japanese Diet over the selection of the Super Tiger has been extensive and bitter.

NORTHROP'S N-156F air superiority fighter was given a go-ahead by USAF, which has decided to support this design so NATO nations can buy it "off the shelf" (see "Overall Capability Is Key to N-156F Design," p. 52).

more on next page



technical management intelligence

AFTER YEARS of supporting research by three firms in the atomic bomber propulsion and airframe fields, USAF settled on Convair-Fort Worth to work with GE's Nuclear Propulsion Division at Evendale, Ohio, in the initial design of a prototype A-bomber. Most of USAF's work will continue to be concentrated on the development of the propulsion system.

However, USAF is still planning to support limited design work at Lockheed-Marietta, which will also continue to operate its Georgia Nuclear Lab to study radiation effects. Studies by the other company in the field, Pratt & Whitney Aircraft, are financed primarily by the Atomic Energy Commission.

Convair, GE, Martin, Sperry contend for Mauler

EARLY selection of the prime contractor on the Mauler anti-aircraft weapon system is being promised by the Army. Current target date is July 1.

The choice will be made among four companies who had Phase I study contracts—Convair, GE, Martin, and Sperry.

NAVY just let a number of substantial contracts. Among them are a \$61.8 million order to McDonnell for the F4H-1 interceptor, \$64.6 million to Raytheon for the Sparrow III air-to-air missile, \$93.3 million to Grumman for the early warning W2F-1 turboprop, and \$101.7 million to Grumman for the twin-jet A2F-1 carrier attack plane.

The A2F-1 award is a cost-plus-incentive contract, the first of its type. If costs are controlled and specific performance objectives are exceeded, the Navy will get the plane sooner and at a lower price, and Grumman will get additional profits. On the other hand, if the performance of the plane, its systems, or costs do not meet agreed norms, Grumman's profits will decrease.

McDonnell's Mercury contract firmed up

NASA'S man-in-space Project Mercury is moving steadily ahead. The space agency has firmed up its \$18 million contract with McDonnell for 12 space capsules, to be delivered over the next 14 months.

LOCKHEED is expanding its activities in several areas. It bought a controlling interest in Seattle's Puget Sound Bridge & Dredging—to "become

eligible for a part in building atomic submarines." The shipbuilding organization will be operated as a Lockheed subsidiary.

Lockheed is also creating a 12-25-member "Lockheed Antisubmarine Warfare Systems Organization" to work with the Navy in combatting the threat of Russia's 450 subs. The group will include specialists in underwater acoustics, nuclear physics, aircraft design and equipment, data processing, electromagnetics, oceanography, and related fields.

TO HANDLE its dealings with foreign nations, aircraft companies, and airlines, the company also created Lockheed Aircraft International. LAI will provide technical and advisory services covering planning, finance, purchasing, material control, engineering, manufacturing, and contracting with Lockheed divisions.

One quarter for electronics out of every defense dollar, predicts EIA

ELECTRONIC Industries Association in its analysis of Defense Department expenditures from '59 to '70 foresees a potential military market of more than \$100 billion during that period. Ultimately, says EIA, nearly 25 per cent of the defense dollar may go for electronics.

Federal Aviation Agency will increase the market for electronics, says EIA, which expects FAA will nearly double its '59 funding level to \$1.2 billion by '64 and reach more than \$2 billion by '70.

Space activities will also involve a jump in electronics spending. EIA expects ARPA to drop from \$455 million in appropriations in '59 to \$170 million in '64. But NASA's '59 authorizations of \$500 million will triple by '64 and reach more than \$3 billion by '70, EIA says.

MISSILE FUNDING will also account for expanded electronics sales. According to EIA, it will rise from \$3.9 billion in 1959 to \$8.2 billion in 1970.

Spending for manned aircraft will drop from \$6.6 billion in '60 to \$3.2 billion in '70, says EIA. Overall, EIA predicts a rise from \$5.49 billion in '59 to \$12.34 billion in '70 for defense electronics—from \$850 million to \$1.94 billion in operation and maintenance, from \$4.15 billion to \$7.62 billion in major procurement and pro-

more on page 26

CASE HISTORIES



Comparator measures dimensions to one-millionth of an inch. One of many pieces of ultra-precision equipment in the New Departure instrument/minature ball bearing laboratories.



In many bearings, various dimensions and surface finishes must be held to within tolerances of one millionth of an inch.

Instrument Ball Bearings Help Missiles Along A Bright Path Of Precision!

CUSTOMER PROBLEM:

Missile guidance system manufacturers require a dependable source for super precise instrument ball bearings. When used in spin axis and gimbal applications, for example, these ball bearings help restrict vitally important drift, through extremely close tolerances and high precision uniformity.

SOLUTION:

New Departure research, development and production facilities were applied to solving the vital problem. Visual evidence of New Departure's success is the bright path of precision written across the skies by Sperry,

AChiever and other guidance systems used in many of the most advanced missiles and space craft. In the case of Sperry's gyrosyn guidance system, for example, New Departure instrument ball bearings are credited with a remarkable 1200% gain in gyro accuracy. Proof enough that New Departure has the know-how and facilities to solve tomorrow's instrument/minature ball bearing design problems in missile and space exploration.

What's more, these New Departure facilities are available for your design development right now! Call or write Department H-5.

NEW DEPARTURE
DIVISION OF GENERAL MOTORS, BRISTOL, CONN.
NOTHING ROLLS LIKE A BALL

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duction and from \$490 million to \$2.78 billion in R&D.

AEROJET-GENERAL and Thiokol will divide the responsibilities for propulsion of Boeing's solid-propellant, three-stage Minuteman missile. USAF gave Aerojet-General an \$85 million award to develop the second and third stages and Thiokol a \$77 million contract covering the first stage. The contracts call for Aerojet to back up Thiokol on the first stage and for Thiokol to back up Aerojet on the other two.

Bomarc B and XQ-4B contracts let by Air Force

USAF LET another major contract—to Boeing for the 400-mile Bomarc B interceptor missile. The \$300 million award includes ground support equipment.

USAF also decided to give Radioplane the go-ahead on the supersonic XQ-4B target drone. The XQ-4B will use the GE J85 turbojet instead of the Fairchild J83 of the XQ-4A (the engine that was killed at the same time as Fairchild's Goose decoy missile). The XQ-4A was to serve as the target for the Bomarc-Sage air defense system and for Terrier, Talos, Sidewinder, Genie, Falcon, Sparrow III, Hercules, and Hawk.

ARMY AND NAVY are still the primary users of copters. Navy placed a \$14 million follow-on contract with Kaman for the HU2K-1 all-weather multi-purpose helicopter. The copter, which uses the GE T58 shaft turbine engine, will make its first flight in the very near future.

Bell got Army contracts totaling \$23 million for the HU-1A and H-13H. It will deliver 110 of the Lycoming T53-powered HU-1As and 60 H-13Hs.

New early warning plane may cost \$1.5 billion

TOTAL SPENDING projected by USAF for a new early warning and control aircraft runs between \$1 and \$1.5 billion. Three designs, submitted by Boeing, Lockheed, and Canadair-Conair, are being considered, but USAF's decision is still several months off.

The plane ultimately chosen may be required to detect enemy missile launchings and also compute the missiles' trajectories.

USAF FIRMED UP its general operating requirement for an off-the-shelf cargo jetliner and

is soliciting bids from Boeing, Douglas, and Convair. Fiscal '60 budget provides funds for the purchase of 10 cargo jets, presumably off-the-shelf aircraft based on the 707, DC-8, or 880.

The winning firm will derive substantial business from the award, for the aircraft will be suitable for both MATS and commercial airline freight operations.

MARTIN-ORLANDO'S two-stage Pershing ballistic missile is moving forward with all developments being handled in parallel rather than in series. Army and engineering test firings will take place simultaneously rather than consecutively.

Working with Martin and Redstone Arsenal on the 500-800-mile missile are Bendix-Eclipse-Pioneer (inertial guidance stable platform); Bulova Watch (fuzing and arming), Thompson Products' Accessories Division (transporter, erector, launcher), and Thiokol (solid fuel propulsion).

A BACKSTOP for the Pershing may come from Chrysler. Company officials believe the 200-mile Redstone and the 1500-mile Jupiter can both be modified to cover the 500-700-mile range.

Subcontracting largely completed on "chemical" planes

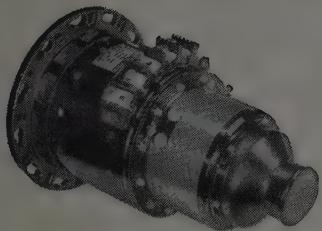
WITH EACH additional subcontract let by North American Aviation for subsystems for the F-108 interceptor and B-70 intercontinental bomber, more companies in the space/aero industry are gaining experience with the problems of Mach 3 aircraft.

Several subsystem contracts have already been let by NAA on each aircraft. Two or three more are still to be awarded on the F-108 and eight more on the "chemical" bomber.

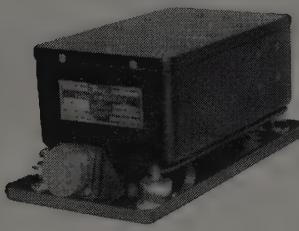
Among the subcontractors for the F-108 are: Federal Telephone & Radio (mission and traffic control), AiResearch (central air data system), Marquardt (air induction controls), Autonetics (automatic flight control system), Hamilton-Standard (environmental control system), Convair-San Diego (wing), Electric Specialties (antenna), and Sundstrand (secondary power systems).

Contractors on the B-70 include: IBM (bombing and navigation system), Autonetics (automatic flight control system), Hamilton Standard (air induction controls), Boeing-Seattle (wing), Chance Vought (horizontal and vertical stabilizers), Lockheed-Marietta (aft fuselage), Solar (engine extraction air ducting system), and Sundstrand (secondary power systems).

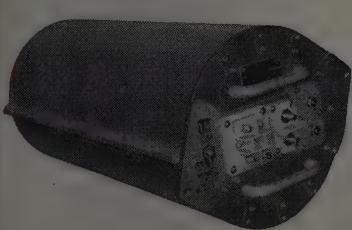
HIGH TEMPERATURE AC GENERATING SYSTEMS



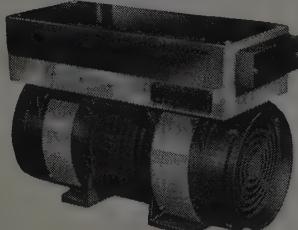
AC Generators



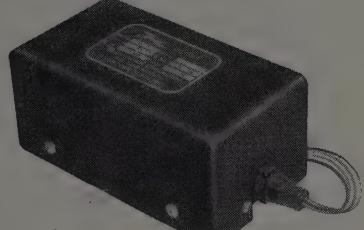
AC Voltage Regulators and SYSTEM COMPONENTS



SPECIAL ENVIRONMENTAL FREE INVERTERS

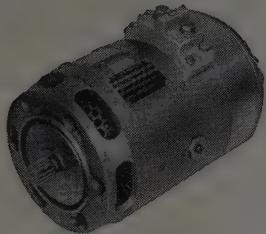


HIGH-ALTITUDE AND MISSILE INVERTERS

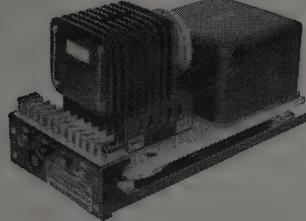


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HIGH TEMPERATURE DC GENERATING SYSTEMS



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CONTROL PANELS

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to find, and not to yield"*
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space/aero engineering intelligence

STEAM PROPULSION for missiles is not as far-fetched as some engineers believe. The Navy is interested in a low-altitude meteorological sounding rocket boosted by a steam propellant motor. A chemical is used to convert water into steam.

Developed by Experiment Inc., Richmond, Va., the "steam motor" is said to be applicable to much larger missiles.

MARTIN'S P6M-2 production SeaMaster seaplane, now being flight-tested, has been fitted with four P&WA J 75 turbojets. The new engines are said to make the production version of the SeaMaster markedly superior to the present YP6M-1 test models. In addition to new engines, the P6M-2 has a redesigned cockpit canopy for increased pilot vision. The wings have been given greater dihedral to allow for higher gross weight capability with the new engines.

Better radiation resistance for rubber tires

"ANTI-RAD" chemical can be added to rubber to extend the useful life of tires on nuclear aircraft. Developed by Goodrich's research center in Brecksville, Ohio, anti-rad is added in chemical form to rubber stocks before vulcanization to improve the rubber's resistance to radiation damage.

Tire life can be practically doubled, says Goodrich. During an 18-month development and radiation testing program, several formulations were studied. Tires were given a severe but not totally damaging radiation exposure, much the same as they would receive from a nuclear aircraft powerplant. They were then subjected to simulated high and low speed landings on a dynamometer tester.

IRRADIATED TIRES containing anti-rad were able to take 25 high speed landings and several low-speed landings before failure. According to research v-p Dr. Frank K. Schoenfeld, the tests showed it is possible to protect rubber compounds against premature failure and to predict the approximate damage from any exposure.

NEODYMIUM, which seems to increase the heat resistance of magnesium for aircraft and missile use, may also be good for steel and aluminum alloys. Since the early '50s, misch metal (a

naturally occurring mixture of rare-earth oxides) has normally been used to adapt magnesium alloys for the 300-500-deg F range. According to Nuclear Corp. of America, Burbank, Calif., experiments suggest that the good qualities imparted by misch metal are due to neodymium. The undesirable qualities—such as decreased resistance to creep—are believed to be caused by other components of the mixture.

Purer neodymium should up heat resistance of metals without ill effects

INDUSTRIAL PROCESS for extracting and reducing neodymium to 98.99 per cent purity has been perfected for large-scale production. It is believed the neodymium, used by itself, will improve the heat resistance qualities of metals without compromising any of the other physical properties.

UNDERWATER detection system designed to pinpoint test missiles launched from the Pacific Coast when they hit the ocean is said to be sensitive enough to detect impacts within a 500-mile radius of the system center. Plans are for a detection network that will stretch from Hawaii to Hong Kong.

Honolulu sources report the system—in the Wake Island area—is built around five 75-mile-long "detection" cables laid out as spokes on the ocean floor. Changes in radiation pattern can be traced first to the wedge-shaped sector bounded by any two cables and then more precisely to their distance from the center. Other underwater detection systems probably will be installed to expand the coverage. . . . Next logical development would be the extension of this technique for detection and tracking of underwater and surface vessels.

Materials problems loom largest in nuclear rocket R&D

OVER 30 PER CENT of the R&D work on the Rover rocket reactor program is going into solving the materials problem. Final design will have to operate at temperatures over three times higher than those of any stationary power reactor in the U. S.

more on next page



RADIOISOTOPE batteries will have only limited space applications. According to Maj. Gen. Donald J. Keirn, chief of nuclear aircraft and missile development for AEC and the Air Force, radioisotopic devices do a good job of supplying small amounts of electricity. But, for space, it appears "the high-powered nuclear reactor turboelectric system in the megawatt range may be the only solution."

HUMAN FACTORS group set up by AEC and the Air Force is responsible for defining the physiological and biological problems of nuclear propulsion—by examining in detail the health and safety characteristics of specific propulsion systems under study or development.

OVER 25 PER CENT of the '60 AEC budget is earmarked for reactor developments aimed at airborne applications: \$12.1 million for nuclear power sources for artificial satellites, \$25.9 million for missile propulsion reactors, and \$68.7 million for aircraft propulsion reactors.

Hundred watts output and one year duration at less than 25 lb converter weight

THERMIONIC converter demonstrated by GE was originally developed on a lab basis just to prove the feasibility of direct conversion of nuclear energy into electricity. Results far exceeded expectations. Tests indicate a power pack generating more than 100 W and lasting more than a year could be built that would weigh less than 25 lb.

Short-lived radioactive gold was used in the demonstration model. GE says the development model would use a long-lived radioisotope such as cerium 144.

AUTOMATIC wire terminal attachment machine was developed by Thomas & Betts, of Elizabeth, N.J. Said to be the first of its kind, it will automatically install individual insulated electric terminals to wires in the AWG 22-18, AWG 16-14, and AWG 12-10 size ranges.

The vibrating feeder bowl of the terminal attachment machine has a capacity of about 1000 terminals. A chute leads each terminal to a staking die that automatically attaches the terminal as the machine operator inserts a stripped wire into the terminal barrel.

MOLECULAR SIEVE system developed by Linde removes both dissolved and free moisture from jet fuel in storage or during transfer to a plane's fuel tanks. The sieves, manufactured in the form of hard pellets about as large as a grain of rice, have highly unusual adsorbent properties. Within each pellet are literally billions of pores large enough to admit water molecules but small enough to keep out the fuel molecules.

Tests by Armour Research Foundation show the water content is reduced practically to zero parts per million even for fuel flows measured in hundreds of gpm. Used pellets can be dried out by heating them, which drives out the water, and can be used over and over again for thousands of cycles.

ABMA's eight-rocket cluster two months ahead of schedule

ABMA's 1,500,000-lb-thrust engine cluster may be flight-tested before November '60. The Huntsville missile group is said to be at least two months ahead of schedule in setting up the eight-engine Juno V cluster, which will have eight Redstone tanks and one Jupiter tank.

POLARIS-LAUNCHING sub fleet is being increased, since Polaris is at least one year ahead of schedule and early flight tests have been so successful. Official confirmation has also come of SPACE/AERONAUTICS earlier report that Polaris will be installed on surface ships.

TWIN-DART executive and medium haul transport is being developed by Avro in England. The Avro 748 will carry 36-44 passengers and will be pressurized. First flight is scheduled for early '60.

BRITISH Seacat short range surface-to-air missile will replace 40-mm AA guns aboard fleet ships. Short Bros. & Harland is producing the missile in quantity for the Royal Navy. Indications are that the British and other armies also want field versions of the Seacat.

NEW NIMONIC 105 alloy developed in Britain from the nickel-chromium-cobalt-molybdenum alloy Nimonic 100 reached production status. Creep resistance is very high. At 940 deg C and under about 15,000 psi stress, the life to rupture is on the order of 50 hours. Under the same conditions, Nimonic 100 is good for 30 hours and

more on page 32



59-33

Around the world in 80 minutes

Phileas Fogg needed eighty days to see what the Explorer scans in minutes. Ex-Cell-O Corporation was not then in business to help speed his trip—it was 1923 that Ex-Cell-O started making aircraft parts to tolerances until then deemed impossible in production.

Forty years of Ex-Cell-O experience in high-precision design and manufacturing have helped hurl the Explorer into the sky—have helped guarantee that Ex-Cell-O rocket and missile components embody the delicate strength essential in space.

Twenty-four Ex-Cell-O facilities in the United States specialize in accuracy by the ounce or by the ton... for the future.

EX-CELL-O FOR PRECISION



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MAN AND MISSILES FLY HIGHER, FASTER AND SAFER WITH PARTS AND ASSEMBLIES BY EX-CELL-O AND ITS SUBSIDIARIES
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Nimonic 95 for only 15 hours. New Nimonic alloy is also more resistant than the others to corrosion set up by solid and molten sulphate contaminants.

MASTER REFERENCE GYRO developed in England weighs 20 lb and measures 14x7x8½ in., including mounting frame, amplifiers, etc. S. G. Brown Ltd., of Watford, Herts., England, says vertical and azimuth gyros are mounted in tandem and in line with the fore-and-aft axis of the stabilized platform, so that the gyro wheel diameters could be made larger.

The current Mark 2 MRG gyro has fully transistorized amplifiers. Present temperature range is -55 to 90 deg C; plans are to raise the limit to 110 deg C. Vertical accuracy is better than 0.2 deg and random drift rates better than 0.25 deg/hr.

Latest gyro version may have inertial accuracy

MARK 3 MRG is in the works. Agreement between Brown and Arma has resulted in a design study shooting at accuracies suitable for inertial navigation. The Mark 3 version will use a pair of two-degree-of-freedom Arma-Brown gyros.

BRITISH TURBOPROPS continue to forge ahead. Bristol's Proteus now has an Air Registration Board approval overhaul life of 2000 hours. Rolls-Royce's Dart R-Da-10 has completed a 150-hour type test in accordance with combined U.S.-UK regulations at a dry takeoff rating of 2660 ehp (2400 shp plus 670 lb jet thrust).

NEW TYPE of movable nozzle for improved steering control of Polaris missile has been tested successfully. Designed by the Systems Engineering Division of Cleveland Pneumatics Industries, it is based on a concept advanced by scientists at the Johns Hopkins Applied Physics Lab. It is made wholly of molybdenum.

VANGUARD II transmitter batteries operated about four days beyond their expected life of two weeks. Enough data have been recorded to make the cloud-cover experiment a success, but an undesirable wobble of the spiraling payload in orbit has made it unexpectedly difficult to interpret the data. It will probably take months to produce the first picture. The big problem is to precisely plot the exact extent of the satellite's wobble, so that then the data can be plotted.

TEMPERATURE CONTROL of the Vanguard II during its first 18 days of orbital flight was held to within one degree of the design value of 110 deg. F. Design calculations were based on the satellite's spending about 68 per cent of its time in sunlight.

FEASIBILITY study of a one-million-pound-thrust solid propellant rocket is being sponsored by Aerojet-General. Company is investing \$250,000 in the study, which it considers a preliminary to developing rockets having up to 10 or 15 million pounds thrust. Dr. Karl Klager, leader of the Propellant Development Division, will be in charge of producing the high energy propellants that will be needed to develop the million-pound thrust.

The first million-pound motor is only a start. Aerojet says once the prototype is tested it could go on to develop within three years a solid rocket producing over a million pounds thrust for periods approaching two minutes.

Solar radiation studied by means of rocket's ultraviolet photos

ULTRAVIOLET pictures of the sun made by sending an Aerobee-Hi rocket to an altitude of 123 miles may provide some clue to the effects of solar radiation on radio communications. Naval Research Lab developed a special 35-lb camera for the job. Instead of lenses, the camera uses grating mirrors to screen out all but the ultraviolet radiation, which is allowed to strike the film.

A photocell stabilization device kept the camera aiming at the sun throughout the rocket's trajectory. It took the first pictures ever made of the hydrogen gas clouds 4000-6000 miles above the surface of the sun. The clouds could never be photographed from the ground, since ultraviolet radiation is absorbed by the ionosphere 40-55 miles above the surface of the earth.

LARGE-SCALE wind tunnel aircraft model built by Vertol for the Army combines deflected slipstream and tilt-wing approaches to VTOL and STOL designs. Wind tunnel tests are expected to yield valuable data on wing and propeller efficiencies, control effectiveness, and aerodynamic loading.

The model has a wing span of 35 ft, an overall
more on page 34

VIGILANTE

The Navy's new all-weather attack weapon system packs a precision punch... for limited war, or all-out conflict

When North American's A3J Vigilante joins the fleet, the Navy will have its first supersonic carrier-based attack weapon system.

Vigilante is so versatile it can strike the restricted targets of limited warfare with extreme accuracy in any kind of weather—or deliver a knockout blow in all-out conflict. It can handle almost any kind of armament, including nuclear weapons, at extended strike ranges, high or low level. In performance, it's on a par with the fastest, highest-flying airplanes in the world today—yet it also operates with superior efficiency for low-altitude, long-range missions. Advanced boundary-layer control and full-span movable leading edge give the A3J good low-speed handling qualities for safe landings on car-

rier decks and short runways ashore.

The A3J is a true weapon system. All electronic systems and auto-flight controls are integrated, and were designed to enable the A3J to carry out all-weather, all-altitude weapon delivery. Its precision bombing-navigation system—outstanding in tactical efficiency—is the result of a coordinated effort by North American's Columbus and Autonetics Divisions.

Most important—the A3J has *men*: a pilot and a bombardier-navigator. For only men can respond to the unexpected. Only men can make decisions and report results. Only men can think. That is why, now and in the future, we must have manned weapon systems like the A3J Vigilante to keep our defense in balance.



Also from Columbus—a new concept in Navy basic training

North American's new T2J is more than just a rugged, reliable, safe, easy-to-service jet trainer. It is an airplane specifically designed to meet the high standards set by the Navy for training carrier pilots. Top speed is 424 knots; stall speed is under 75. Engine can be removed in 7 minutes, replaced in 20. The T2J was designed, engineered, tested—and is now being produced—at the Columbus Division.



THE COLUMBUS DIVISION OF NORTH AMERICAN AVIATION, INC.

Columbus, Ohio





length of 27 ft, and a gross weight of about 14,000 lb. Its 16-ft horizontal stabilizer can be mounted in three positions: on the fuselage, at the top of the fin, or in between the two.

VERTOL'S MODEL has a high tiltable wing and two single-slotted flaps for deflecting the slipstream from six props. These are driven by a 1000-hp, variable-frequency electric motor mounted in the fuselage. Wing tip panels are detachable so that the model can be tested with four props at reduced wing span.

Vanguard I data are used to correct errors of one mile on maps

FIRST YEAR'S accumulation of Vanguard I satellite data is being used to correct map errors. Some land areas as much as a mile out of position on the maps are being relocated with an accuracy of about 250 ft.

One radio transmitter aboard the satellite is still sending out signals. Powered by solar batteries, it should last indefinitely. Estimates of the satellite's expected life range from 200 to 1000 years.

MERCURY dummy models weighing two tons are being used in recovery and emergency launching escape experiments. In early tests, full-scale dummy capsules jettisoned from a plane into the ocean have been recovered intact.

Next step is to see how capsules withstand impacts on solid ground. Preliminary experiments have dealt mainly with the use of different materials—with crushable honeycomb structures of corrugated plastic and aluminum and with fibrous cellulose materials. Small-scale models are being dropped on hard surfaces from all impact angles to find the most vulnerable contact conditions.

NUCLEAR engineering test facility at WADC should be in operation by early '61. It will be operated as a central service facility on a priority basis for the 11 WADC labs, other ARDC centers, AEC, and DOD agencies, and special contractors working on nuclear projects.

Experimental program for the NETF ranges from large-volume radiation effects testing to fundamental research. This will include radiation effects studies and testing under simulated nuclear service operation conditions, development of materials and systems with improved radiation re-

sistance, shielding design studies, airborne reactor instrumentation and control component and system studies; development of handling and servicing techniques, production of tracer radioisotopes for WADC use, and radioactivation analytical techniques.

NEW CONCEPT for man-seat separation in aircraft emergency escape systems was proved out by Talco Engineering, of Mesa, Ariz. Key to the system is an automatically operated, ballistic rotary actuator energized by a solid propellant. The actuator is mounted behind the pilot at the top of the aircraft seat. A strap attached at one end to a reel in the actuator and at the other end to the front of the seat fits snugly behind and under the pilot.

When the seat and pilot are ejected, the solid propellant is ignited. The gases rotate the wheel to quickly wind in the reel and stretch the strap taut. Result is the pilot is "kicked" away from the seat.

Aircraft periscope to give a normal field of vision

ONE-INCH-HIGH periscope for supersonic planes has been developed by American Optical, of Southbridge, Mass. It is designed to replace conventional windshields. Built with cylindrical lenses rather than the conventional spherical ones, it gives the pilot a natural, normal-size view of what is in front of him.

AUSTENITE in high strength steels is believed to lower the fatigue strength. Experiments conducted by the Bureau of Standards in cooperation with the University of Maryland show that retained austenite, in increasing amounts up to 10 per cent, lowers fatigue strength. Tests also demonstrated that fatigue stressing transforms retained austenite to untempered martensite, which probably accounts for the deleterious effect.

Test specimens were made of four low-alloy steels whose carbon contents ranged from 0.44 to 1.06 per cent. For each steel, the fatigue strength decreased as the amount of retained austenite increased. But for the three higher-carbon steels there appeared to be a limiting value of about 10 per cent beyond which the strength did not change. Specimens refrigerated before tempering were also observed to have greater fatigue strength than unrefrigerated ones. Contrary to results of other studies, no significant difference in fatigue strength was caused by an interrupted quench.



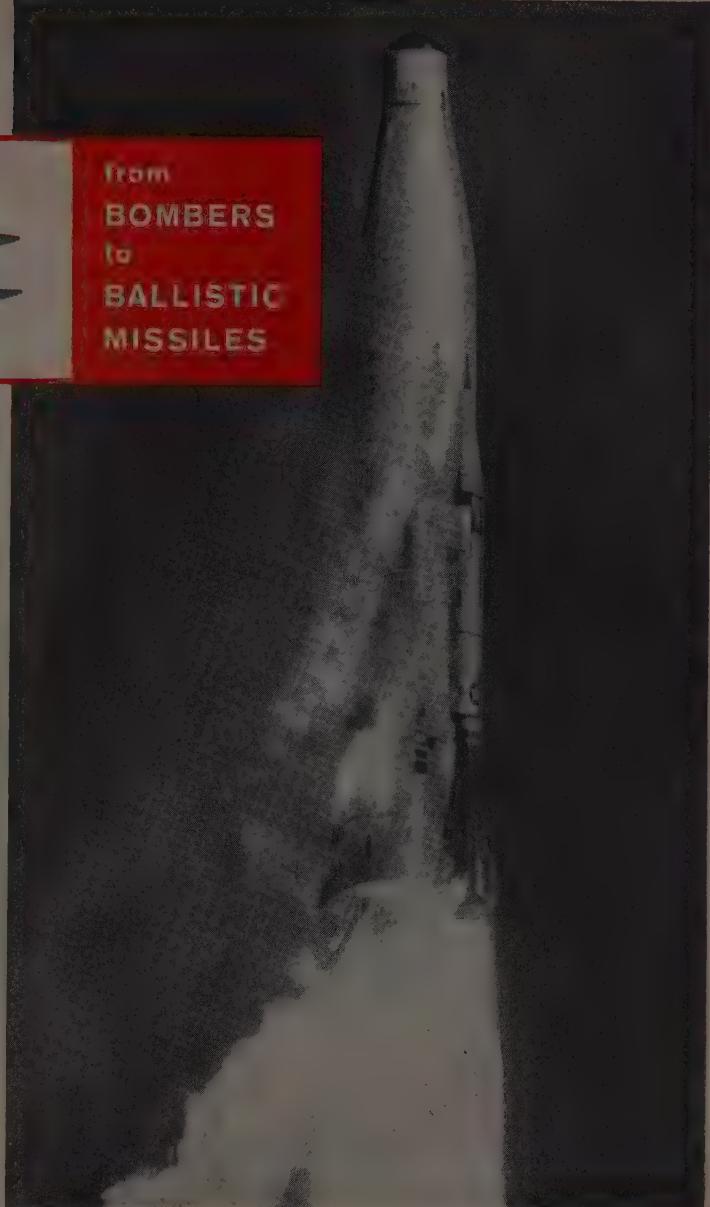
from
BOMBERS
to
BALLISTIC
MISSILES

ESNA has serviced the special fastening problems of the aircraft industry

About the only point of similarity between the *Curtiss-Condor* bomber and the *Atlas* is the job both were designed to do. The inter-continental *Atlas* typifies the design progress of the aircraft industry in a short span of years.

The ever increasing speeds demanded for new missiles and aircraft have called for constant changes in fasteners—making them smaller, lighter and stronger—all at the same time. The result of ESNA's 28 years of serving the changing needs of the aircraft industry is the largest and most varied line of self-locking fasteners available from any source. ESNA is ready to continue to match fastener progress to aircraft and missile progress—making new Elastic Stop nuts to meet new requirements.

Complete design details of ESNA's line of aircraft fasteners are yours for the asking. Write to Department 327-550.

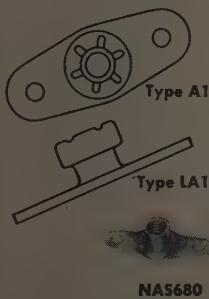


The *Atlas* is built by the Convair Division of General Dynamics Corporation.



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In 1931, the pioneers of the aviation industry were designing the first metal airplanes. One of the major assembly problems was the need for a safe, blind type of fastener which would permit assembly and disassembly of sections from the outer side. ESNA created a "special" part . . . the first two lug anchor nut.

As increasing emphasis was placed on weight savings ESNA "shaved" dimensions and created the first lightweight two lug design (LA1) in 1944 . . . which has now evolved into today's standard NAS680. The continuing special requirements of the aircraft industry have resulted in many modifications of that first two lug design . . . such as those illustrated below . . . all available from ESNA.



Miniature



Beveled Sides



Deep Csk.



Floater



Deep Cbore.

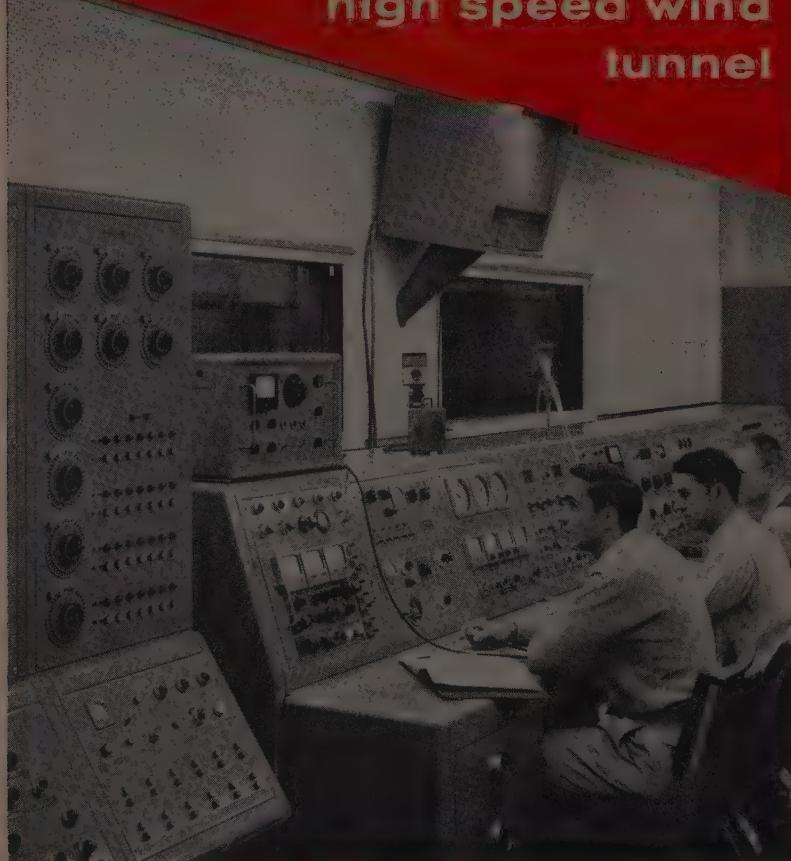


Self-Aligning

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EMCOR CABINETS

house nerve center of new
high speed wind
tunnel



From single unit to a major system... EMCOR human engineering is incorporated in the Modular design of all cabinets. Shown above is the popular Low Silhouette Cabinet... just one of the complete EMCOR Standard Line.

Operators manipulate tests and record data on supersonic high altitude and space project vehicles under design and development at the new Chance Vought Aircraft, Incorporated high speed wind tunnel, Dallas, Texas. Standard cabinets of the EMCOR MODULAR ENCLOSURE SYSTEM house the nerve center of the high speed wind tunnel. EMCOR Standard Cabinets with their exclusive combination of patented custom quality features eliminate costly design time guesswork. The flexibility and versatility of EMCOR Cabinets are proving themselves daily in major control center applications. Let EMCOR Engineering Know-How answer your housing problem.

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calendar

May 3-7—Symposium on Electrode Processes, AFOSR/Chem. Div. & Electromechanical Society (for data, Electromechanical Society, Inc., 1860 Broadway, New York), Philadelphia, Pa.

May 4-6—National Aeronautical Electronic Conference, Institute of Radio Engineers, Biltmore Hotel, Dayton, Ohio.

May 4-6—Fifth Annual Flight Test Instrumentation Symposium, Instrument Society of America, Seattle Section, Olympic Hotel, Seattle, Wash.

May 6-8—1959 Electronic Components Conference, Benjamin Franklin Hotel, Philadelphia, Pa.

May 11-13—National Power Instrumentation Symposium, ISA, Kansas City, Mo.

May 11-15—"Medical and Human Engineering Aspects of Flights," Aeromedical Panel and Flight Test Techniques and Instrumentation Panel, AGARD, Athens, Greece.

May 12-14—Production Engineering Division Conference, American Society of Mechanical Engineers, Statler-Hilton Hotel, Detroit, Mich.

May 15-16—Spring Meeting, Society of Aircraft Materials and Process Engineers, Eastern Div., Hotel Statler, New York, N. Y.

May 18-20—Fifth National Symposium on Instrumental Methods of Analysis, ISA, Shamrock-Hilton, Houston, Texas.

May 18-21—18th Annual National Conference, Society of Aeronautical Weight Engineers, Hotel Henry Grady, Atlanta, Ga.

May 20-22—Second Jet Age Airport Conference, American Society of Civil Engineers, Shamrock-Hilton Hotel, Houston, Texas.

May 20-22—National Spring Meeting & Exhibition, Society for Experimental Stress Analysis, Sheraton Park Hotel, Washington, D. C.

May 21-22 — 1959 Ohio Valley Instrument and Automation Exhibit and Symposium, Cincinnati Section, ISA, Music Hall, Cincinnati, Ohio.

May 24-June 5 — Federation Aéronautique Internationale, Annual Meeting, Moscow, USSR.

May 25-27 — 1959 National Telemetering Conference on Investigation of Space, American Rocket Society, Institute of the Aeronautical Sciences, American Institute of Electrical Engineers, ISA, Brown Palace and Cosmopolitan Hotel, Denver, Colo.

May 25-28 — Design Engineering Conference, ASME, Philadelphia Convention Hall, Philadelphia, Pa.

May 26-28 — Supersonic Transport Meeting, San Diego Section, ISA, San Diego, Calif.

June 1-3—IRE Professional Group on 1959 PGMNT National Symposium, Paine Hall, Harvard U., Cambridge, Mass.

June 8-9 — Industry Missile and Space Conference, Aero Club of Michigan, Sheraton-Cadillac Hotel, Detroit, Michigan.

June 8-11 — Semi-Annual Meeting and Astronautical Exhibition, ARS, El Cortez Hotel, San Diego, Calif.

June 8-12—"Chemistry of Propellents," Combustion and Propulsion Panel, AGARD, Paris, France.

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fly with the X-15 into space

The diagram illustrates the X-15's flight path. It starts with a launch from Edwards AAFB, followed by a path through the atmosphere. Labels indicate 'RE-ENTRY HEATING' and 'LEAVE 99.9% ATMOSPHERE'. The aircraft then enters a 'BEATTY RADAR TRACK' and a 'ELY RADAR TRACK'. Finally, it lands at Edwards AAFB during a 'GLIDE LANDING'. Temperatures are marked as '1000° F' on the re-entry heating section and '-300° F' on the glide landing section.

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Should we go to the metric system?

Many engineers and scientists want to drop the inch-pound system. Others want to keep it. Here's a chance for you to let us know which system you want.

by Randolph Hawthorne, Editor

STRONG and mostly favorable response has been given to our editorials on the metric system vs the English one in the space/aero industry. If letters from our readers are a true reflection of their problems, then something should be done. SPACE/AERONAUTICS plans to do something. On the opposite page is a questionnaire designed to be a key factor in our plans. Everyone who wants the metric system of weights and measures in place of the customary English system is urged to fill out the questionnaire.

But, just as important, everyone who doesn't want any change in the present situation of legalized metric and customary, but never legalized, English system, also is urged to answer all questions.

On the basis of your replies, the editors of SPACE/AERONAUTICS will take appropriate action in co-operation with interested technical societies.

No such thing as "standard" inch

Right now, there is no standard "inch" among the countries using the English system. According to Dr. A. V. Astin, National Bureau of Standards director, "Each of three major English-speaking and inch-using countries—the U.S., the United Kingdom, and Canada—has a different inch. The differences between these inches are such that a precise reference standard, such as an end standard or gage block, calibrated according to the standards of one of these nations, will probably fail to meet the tolerances in the other two."

"These differences," Dr. Astin went on, "resulted in some confusion and inefficiencies during World War II. With the continual need for and trend to increased precision in the years ahead, these differences, unless resolved, will become increasingly important obstacles in the future exchange and mutual use of precision instruments and components."

As a result of this situation, new international inch and pound standards have been agreed upon. They will go into effect July 1, 1959. The new inch will equal 25.4 millimeters, instead of the present NBS inch, which is equal to 25.4000508 mm. The new pound will equal

0.45359237 kilogram as compared with the present pound of 0.4535924277 kg.

The new "international" standard will resolve some of the difficulties of the inch-pound countries. But the thorniest problem stems from the fact that inch and pound must be calibrated to metric measurements. For the metric is the legal system.

Tedious, error-producing conversions between the two systems are the result. This has been pointed out by our readers.

Arguments in favor of changing over wholly to the metric system are:

- **Convenience**—Scales are readily available with decimal divisions; only decimal point changes are needed between large and small units; metric values are understood by all scientists; the metric system is faster in use.

- **Accuracy**—Conversion factors are eliminated, which now are a source of possible errors in every engineering calculation that requires them.

- **Time and Labor**—These will be reduced by using the metric system exclusively from the lab through design and production. Feedback of data from test vehicles, also in metric units, will be easily applied.

- **Communication**—Interchange between present inch-pound countries and metric nations will be according to a universal standard.

Change should be made gradually

If a changeover to the metric system is recommended, we believe the change should be gradual. One reader has recommended that the start be made in space technology. He pointed out that magnitudes are not firmly established in our minds in this area. Their meanings, therefore, are so different from those we are familiar with that comparison doesn't mean much.

But, whether we change to metric or not, the answer is partly up to you. If you believe we should change, fill out the questionnaire. If you don't want a change, fill it out. We need more than opinion to go to bat for you.—End

SURVEY: THE METRIC SYSTEM

THIS SURVEY is to find out how you—who work in the technologies concerned—regard the present system of weights and measures prevailing in industry. Do you want it changed, or do you want it the way it is?

To get the answers that will enable SPACE/AERONAUTICS to coordinate with your professional societies, and to approach Congress with documented evidence of the requirements of your profession, we

ask that you fill out this questionnaire as completely as possible. It should take no more than five minutes. An important factor will be your estimate of the manhours used in making conversions from English to metric measurements, or vice versa, in your engineering calculations.

Please mail the completed questionnaire to Space/Aeronautics, 205 E. 42nd St., New York 17, N.Y.

I: System in Use

- (1) Do you use **metric** units in your work exclusively? Yes No
- (2) Do you use **metric and English-system** units in your work? Yes No
- (3) Do you use **English-system** units in your work exclusively? Yes No

II: English-Metric Conversions

- (1) How many manhours do you estimate you devote to conversions from one system to another in your work per month?
Number of hours
- (2) Many readers have said that conversions introduce errors into computations. Do you agree this is possible? Yes No
- (3) If "yes", would you say the accuracy of computations would be improved by using the metric system only? Yes No

Name (Optional): Title:

Dept.: Section:

Company or Profession Affiliation:

Location (State):

Additional Comments:

III: Recommendations

- (1) Do you recommend using the metric system **exclusively** throughout the space/aero industry?
 - (a) Immediately (b) Gradually
 - (c) Starting in space technology areas only (d) Other (specify):
- (2) Do you recommend **no change** at all that would substitute the metric system for the English?

IV: Technical Areas of Activity

- (1) What is your field of professional activity?
 Basic research Production
 Applied research Test
 Development Theoretical analysis
 Design Procurement
 Technical Administration
- (2) Technical Society Membership:
 IAS ARS SAE ASME IRE
 ISA Other (specify):



TO FIND OUT about Navy programs for the coming decade, Space/Aeronautics interviewed (l. to r.) Rear Adm. K. S. Masterson, Director of Guided Missiles; Vice

Adm. R. B. Pirie, Deputy Chief of Naval Operations for Air; Rear Adm. J. E. Dodson, BuAer's Assistant Chief for Procurement; and other Navy brass.

Navy plans for the sixties

- More versatile missiles
- Low level attack planes
- Tighter contracting procedures

by Robert M. Loebelson, Associate Editor

THE NAVY BELIEVES it has one of the most important defense jobs in this era of ballistic blackmail. It is certain the U.S. could not win any future conflict without full-scale participation by Naval aircraft and missiles.

Some of the reasons why the Navy feels this way were given to SPACE/AERONAUTICS by Vice Adm. Robert B. Pirie, Deputy Chief of Naval Operations for Air; Rear Adm. Kleber S. Masterson, Director of Guided Missiles; and Rear Adm. J. E. Dodson, BuAer's Assistant Chief for Procurement. This is what they re-

ported in a rundown of Navy planning for the next decade:

- *Air-Launched Ballistic Missiles*—The Navy has concluded it needs no air-to-surface missiles in the 500-1000-mile range. However, it will require a stand-off weapon like the Temco Corvus, which would be air-launched about 150 miles from the target. The Navy's prime interest is in missiles to attack enemy ships or coastlines.

- *Surface- and Subsurface-Launched IRBMs*—There is a definite requirement for solid propellant IRBMs to be launched from surface ships. These would be relatively minor conversions of the Lockheed Polaris, which will be fired from atomic submarines. If the case is proved for sea-borne deterrence, it follows that surface

ships would be almost as effective as subs, because the submarine's only advantage over the surface ship is concealment. Many existing Navy surface ships would be modified to fire Polaris-type IRBMs.

The atomic-powered Polaris subs will be equipped with the latest defensive devices. Among these will be the Goodyear Subroc underwater-to-air-to-underwater missile.

- *Talos as Anti-Missile*—While the Talos was once considered suitable for development into an anti-ICBM, it is now believed the fire control equipment would be too bulky. However, advanced versions of the Talos will be suitable for use to defend ships against stand-off missiles and perhaps even air-launched ballistic missiles. The Navy considers its best defense against enemy ballistic missiles to be the twin policy of "keep the ships moving" and "get the enemy before he gets close enough to do damage."

- *Decoy Missiles*—The Navy has an active interest in and increasing requirements for decoy missiles.

- *Use of USAF Missiles*—Several Navy missiles have been taken over by the Air Force, but no USAF missiles are being acquired for Navy use. The reason lies in the Navy's special environmental problems (such as more stringent safety requirements aboard ship). But this does not mean that Navy would never use AF missiles—each service studies the other's missiles all the time for possible adaptation.

- *Mach 3 Aircraft*—There is a good deal of doubt as to whether the Navy will ever require this type of aircraft. In air defense, a relatively slow airplane in the Mach 1+ category can do the job by firing a high performance missile, such as the Bendix Eagle.

Low-level attack favored for planes

The present generation of all-weather fighters is about as far as the Navy plans to go. For attack purposes, a plane's best chance of reaching the target, as the Navy sees it, is at low levels—and Mach 3 speeds are not needed for that, either.

- *Water-Based Aircraft*—The Navy has not lost interest in seaplanes for anti-sub work. For attack purposes, however, it has concluded that the Polaris is a better weapon than the Martin P6M SeaMaster. The forthcoming P6M squadron will be used to determine the operational problems of large seaplanes.

For anti-sub warfare, the Navy is undertaking a design study of a piston engine or turboprop seaplane. High speeds are not required for anti-sub patrols.

- *Nuclear Aircraft*—The Navy has long advocated that the U.S. get a nuclear plane flying so that we can learn everything possible about the problem. The Navy's uses for such an airplane would be in the early warning, anti-sub patrol, and reconnaissance. At the present state of the art, nuclear aircraft would not be economical for these jobs.

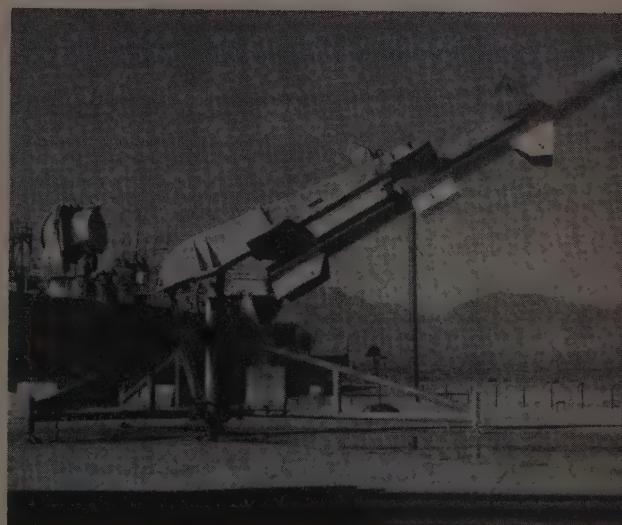
The Navy would like to acquire the British Saro Princess flying boat as a test vehicle and install nuclear engines in it. But it does not have enough funds of its own for this program and is therefore seeking Defense Department support.

- *Freighters and Trainers*—The Navy is pretty well

more on next page



POLARIS IRBM, slated for installation in subs, eventually will also be fired by a wide variety of surface ships, the Navy expects.



TALOS surface-to-air missile will be used against stand-off missiles and maybe even against air-launched ballistic missiles once its development is further advanced, the Navy hopes. In this role it would serve to defend our ships. Former hopes of developing the Talos into an anti-ICBM missile have been given up by now.



MARTIN P6M SEAMASTER—shown here with its beaching vehicle—has been scrapped as an offensive weapon in favor of the Polaris IRBM. However, this doesn't mean the Navy has lost interest in seaplane development. It will use the limited number of SeaMasters it has ordered to study the operational problems of large aircraft of this type.



BRITAIN'S Saunders-Roe Princess flying boat has attracted the Navy's interest as a possible testbed for nuclear engines. The Navy, which has long advocated the development of nuclear flight in the U. S., claims it would have a variety of uses for an atomic plane. It also claims it doesn't have the money for a development program of its own (which would include the purchase of a Princess), therefore is seeking Defense Dept. support.

out of the logistic aircraft business. On the other hand, it is definitely interested in smaller jets as navigation trainers. It may therefore buy aircraft of the Lockheed JetStar, NAA Sabreliner, and McDonnell 119 type.

• *Engine Development*—In spite of appearances, the Navy and Air Force have never had an agreement covering sponsorship of turboprops and turbojets. Both services will continue to develop engine types they require and will make the results available for use by the other service. Even though several new turbojets bear Navy numbers (P&W's J52, J58, and J60), they are designed for Army and Air Force applications at present.

• *Active Aircraft*—The Navy expects to have only 7200 operational aircraft by the end of fiscal 1970—a sharp drop from the nearly 10,000 active aircraft only two or three years ago. An additional 2000 planes will be in the Navy inventory by June 30, 1960. However, the sums being requested from Congress do not cover enough replacements to maintain the 7200 level. The number of aircraft the Navy will operate after 1960 will depend in large part on Congress.

• *Space Activities*—The military uses of space flight are still somewhat obscure, the Navy believes. The Army and Air Force have or are developing vehicles that the Navy would use if we have space requirements unfilled by the other services. If the Navy should find it would need special engines to get into space, it would have to fight for funds to develop them.

• *Industrial Teams*—The growing complexity of weapon systems will call for wider use of the team-bidding approach and greater emphasis on the weapon system concept. The Navy has no plans to abandon completely the policy of developing some missiles within its Bureaus, but it will also place more reliance on industry talent.

• *Relations with Contractors*—Although many traditional Navy suppliers have been hurt as a result of recent contract cancellations, the Navy plans no direct action to insure their survival. However, the Navy would like to see all of these companies pick up enough sub-contracts to continue in business. There is no program to make certain that a company that lost out on one competition comes out on top in the next one.

• *Airframe vs Electronics Firms*—Although electronics will account for a greater percentage of the dollars in future weapon systems, the amount of Navy dollars going to airframe contractors in the future will not drop. This is because many of the old-line companies have diversified and also because the aircraft industry has the management know-how. Electronics firms (with a few exceptions) have not yet acquired this management know-how, the Navy believes. Nevertheless, many prime contracts are going and will continue to go to electronics organizations.

• *Changes in Contracting*—The Navy must sharpen up its contracting techniques, especially in view of the cost of new weapon systems and their limited production runs. In general, the Navy will rely on contracts similar to the ones now being signed but will try to make its contracting officers more knowledgeable.

One new contract type being tried in an effort to hold down costs while getting better weapons is a cost-plus-percentage agreement. Under this contract the producer's incentive return depends a third on how well he keeps the price down, a third on how well the airplane performs, and one third on how well the systems within the plane operate.—End

Time dilation in space travel

or, How to stay young (relatively, that is)

We know that manned interplanetary travel will soon be feasible—certainly within our lifetime. And it's not unreasonable to expect that after that we will be able to develop the equipment we would need for interstellar travel (though it may take a very long time). But there's another question to be answered before man can take off for Alpha Centauri, for instance, and that one involves the most intriguing of all the puzzles of space flight: the application of Einstein's theory of relativity.

by **Kurt R. Stehling**
Contributing Technical Editor

ELECTROMAGNETIC or light waves take about four years to cover the distance between the earth and Alpha Centauri, one of our near stars. So even for a space ship traveling at the speed of light—i.e., about 186,000 mps—the trip to Alpha Centauri and back would be a long one.¹

Now it is quite unlikely that any space ship will ever travel at the speed of light—for one thing, there is the question of the infinite propulsive energy that would be needed for that kind of speed and for another there is the question of what would happen if a craft barreling

¹ We are assuming, of course, that man will have decided that getting to Alpha Centauri is worth all the immense trouble it will involve even under the best of circumstances.

along at 186,000 mps collided with even a small stone in the garbage-cluttered vastness of space. It's obvious that travel to Alpha Centauri would not have to be measured in years but rather in centuries, even for a vehicle traveling at a dizzying 5000 mps.

Apparently, then, interstellar exploration involves an almost unimaginable closed ecological cycle stretching over many generations. The space pioneer leaving the earth for Alpha Centauri wouldn't have the slightest chance of ever reaching his goal. That he would have to leave to his descendants of the third or fourth generation (all born aboard the spacecraft). And it would be only the descendants in turn of these actual explorers who would return to earth to report on what their ancestors found on Alpha Centauri.

You would think that, as soon as the first space enthusiast wondering about interstellar travel had come up against this centuries-long ecological cycle, all talk about getting to Alpha Centauri would have stopped right away. It didn't. There are many enthusiasts who staunchly maintain that interstellar travel is not unimaginable.

Classical concepts do not apply

They point out that the need for the ecological cycle we have described is derived from the classical concepts of space and time. And these concepts, they claim, do not apply. What does apply—and makes the whole business much "simpler"—is some theorems about relativity formulated by Albert Einstein over half a century ago.

Einstein's restricted theory of relativity included a theorem dealing with "the behavior of measuring rods and clocks in motion." Seemingly insignificant in 1905,

more on next page

Special Theory

Postulate I: The absolute velocity, or steady (unaccelerated) motion, of a system in free space cannot be detected or measured.

Postulate II: The velocity of light in free space is the same for all observers independent of the velocity of the observer and of the light source.

These postulates, taken together with Einstein's definition of the simultaneity of two events at different points in space, yield the following differential form of the transformation of two rectangular coordinate systems $S(x, y, z, t)$ and $S'(x', y', z', t')$, assuming the origin of S' moves at a constant velocity (V) along the x -axis:

$$dx' = (dx - Vdt)/\sqrt{1 - V^2/c^2},$$

$$dx = (dx' + Vdt')/\sqrt{1 - V^2/c^2},$$

$$dt' = (dt - Vdx/c^2)/\sqrt{1 - V^2/c^2},$$

$$dt = (dt' + Vdx'/c^2)/\sqrt{1 - V^2/c^2},$$

where c is the velocity of light, or about 186,000 mps; dx and dt represent the differences in x -position and time, respectively, of a given pair of adjacent events as measured in S ; and dx' and dt' represent the corresponding differences in S' .

Time Dilation: An interval of time dt' , measured by a single clock in S' , between two events occurring at the same point of S' (so that $dx' = 0$) will be measured by an observer in S as:

$$dt = dt'/\sqrt{1 - V^2/c^2}.$$

Similarly, a time interval dt measured in S between two events at the same point of S (so that $dx = 0$) will be measured by an observer in S' as:

$$dt' = dt/\sqrt{1 - V^2/c^2}.$$

In both cases the clock in the observer's frame of reference is going faster than the clock moving past him at V by a factor $1/\sqrt{1 - V^2/c^2}$. If the observer were watching a one-second ticking clock moving at V , he would note that, according to his clock, stationary with respect to the first clock, the time elapsed between two ticks of the moving clock is not one second but one second times $1/\sqrt{1 - V^2/c^2}$.

The time interval produced by $1/\sqrt{1 - V^2/c^2}$ is only slight for low values of V (say, below 0.8c). However, it becomes quite large as V approaches c , and it is infinite for $V = c$! So a space traveler moving at the speed of light would have an infinite life time — in other words, he'd be immortal.

A parallel effect would be the physical shrinkage a "stationary" observer would note in a measuring rod moving past him at V (assuming the rod is pointed in the direction of motion). The "shrinkage" factor in this case is $\sqrt{1 - V^2/c^2}$. At $V = c$, a space traveler would shrink to nothing — as is suitable for an immortal, to the earth-bound observer he would have no physical existence.

General Theory

The general theory of relativity takes account of gravitation and acceleration, which are neglected by the special theory. These two phenomena to some extent modify the time dilation effect, or clock paradox, leading to the conclusion:

"Clocks at a higher gravitational potential (than a com-

parison clock) will be observed to go faster (than the comparison clock)".

In other words, a clock in free space and therefore moving uniformly would keep slower time than an accelerating clock, such as a clock on earth affected by the acceleration of gravity.

this little theorem over the last few years has become the basis for several interesting mathematical exercises showing that time changes are different for observers on a moving body and observers on a body at rest.

duced in the direction of motion (in the so-called Fitzgerald contraction).

- A moving "clock" keeps slower "time" than a "clock" that is stationary, or fixed with respect to the moving "clock". Therefore, "time" passes more slowly for an observer on a moving vehicle than for one in a stationary system.

The application of Lorentz' time change, or time "dilation",² has been discussed in a number of recent scientific papers and articles. The basic question of this discussion was and still is how "real" is the time

(2). Many physicists of polysyllabic tendencies use "dilatation" instead of "dilation". For all practical purposes, the two words are interchangeable.

dilation? This problem perhaps was made clearest in a lengthy dispute carried on in the pages of *Nature*, an English magazine. W. M. McCrea, a scientist at the University of California at Berkeley, published an article showing mathematically that time dilation is not just a mental exercise but indeed a real thing and overcomes the problem of the time lapse of interstellar travel. McCrea claimed that Einstein's theories "proved" that time would "shrink" (relatively) for an interstellar traveler—while the folks back home on earth would sense centuries of time lapse, the traveler to a near star, such as Alpha Centauri, if he moved at nearly the speed of light, would sense only a few decades.³

"Triumph of magic over reason"

McCrea's claims were spiritedly attacked by Herbert Dingle, a scientist and philosopher at the University of London, who denounced them as "dangerous" and "a triumph of magic over reason." According to Dingle, McCrea's interpretation of the Fitzgerald contraction and the clock retardation effect was hopelessly wrong. "Physicists should not have been misled by such words as 'contraction' and 'retardation' into supposing that the objects said to experience these effects suffer changes analogous to those produced by low temperature or by lengthening a pendulum," he explained.

It must be said that Dingle used mainly rhetoric and polemic to advance his argument. McCrea, on the other hand, could point out that he had proved quite rigorously—at least on paper—that time dilation is real in the full sense of the word.

Einstein offered no clear proof

Most scientists who have wrestled with the problem of time dilation in space travel near the speed of light appear to agree basically with McCrea rather than Dingle. That nevertheless the matter is far from being settled is not surprising—the theory of relativity is a rather philosophical piece of mathematics, and especially its concept of time is hard to take except as an unprovable mathematical exercise.

We must remember that Einstein "merely" stated and explained the apparent paradox of time dilation.⁴ He did not offer any rigorous proof—certainly none that could be verified in the lab or by astrophysical measurements.

Time dilation may soon be verified

However, this situation may very well change quite soon. For we have recently had some faint indications of how the time dilation effect might be verified.

For some years, mesons passing through the upper part of the earth's atmosphere have been measured for their kinetic energy and decay rate. We know that a mu-meson decays into an electron, emitting gamma

(3) We might note here that Einstein's restricted and general theories of relativity "look at" time dilation differently, since the restricted theory neglects acceleration and rate of change of motion. It seems that in many space travel schemes the time dilation effect is influenced by rates of change of speed. Acceleration, on the other hand, seems to have no significant effect.

(4) Since motion is relative, the earthbound observer can pull a surprising switch on the space traveler who claims that his "clock," keeping slower time, showed less of a time lapse. "You stood still and I moved," the earth observer can say. "So you took longer than my clock shows." Since it's impossible for both of them to be right, we have a paradox.

radiation and neutrinos in the process. The measured mean life of a mu-meson at rest is 2.1×10^{-6} seconds. In this time, a mu-meson traveling at the speed of light could be expected to cover 600 m.

Experiments with satellites proposed

Now the average height of formation of mu-mesons in the atmosphere is 16 km. Therefore, if the average mu-meson decays after traveling 600 m, only a minute proportion of mu-mesons should ever reach the surface of the earth. Oddly enough, *a large proportion of mu-mesons reaches the earth*. This fact can only be explained if we assume that time dilation slows down the rate of decay of the moving mu-mesons with respect to mu-mesons at rest.

Other recent measurements of mesons and similar particles have confirmed the time dilation of rates of decay (which, of course, correspond to the "clock" of Lorentz' model). They also confirmed that the effect becomes appreciable only near the speed of light.

Further proof may be provided by experiments with satellites. S. F. Singer, of the University of Maryland, and others have proposed that an atomic clock be installed on a satellite or maybe even on the moon. Moving many thousands of mph faster with respect to a clock on earth, the satellite clock would show a small time change—perhaps only a few parts in many millions, but enough to be measured.

The writer has suggested a "radioactive-decay clock" whose particle count, or decay rate, aboard a satellite would be recorded on tape, film, or an integrating counter. After recovery, this decay rate would be compared with that obtained from a comparable sample of radioactive material that had been kept on earth.⁵

Time dilation probably is "real"

Regardless of the amount of proof such experiments may provide, with a little daring we can say already that time dilation in all likelihood is real. Some day therefore it may remove the biggest barrier to interstellar travel. An explorer could take off to Alpha Centauri confident that he himself would actually reach the star. While the earth's clock ticked off centuries, he would sense nothing unusual in his interstellar craft—*within his frame of reference*, his "clocks" (including his body) would show only a time lapse well within the normal human life span.

Of course, when our explorer got back to earth, his friends who saw him off would long be dead and he'd be confronted with their great-great-great-great-grandchildren. How he would get along under these circumstances is another story, which we won't go into here and now.—End

References—H. Dingle, "A Problem in Relativity Theory," *Proc. Phys. Soc.*, vol. 65, p. 925 ('56). A. Einstein, *Annalen der Physik*, vol. 17, p. 891 ('05). W. H. McCrea, "Relativity Physics," Methuen, London ('47). R. C. Tolman, "Relativity, Thermodynamics and Cosmology," Oxford ('34). R. L. Shepherd, *Journ. Brit. Interpl. Soc.*, vol. 11, pp. 155 & 298 ('52). S. F. Singer, "Application of an Artificial Satellite to the Measurement of the General Relativistic Red Shift;" *Phys. Rev.*, vol. 104, p. 11 ('56). K. R. Stehling, "Space Travel and Relativity;" *Jet Prop.*, vol. 26, p. 1105 ('56). W. F. Campbell, "The Clock Paradox;" *Can. Aero. Journ.*, 4/9, p. 316 ('58).

(5) Direct telemetering of the decay data apparently would yield confusing results. However, the data could be telemetered after they had been stored on tape or in some other form.



FAIREY ROTODYNE uses unloaded rotors, is almost certain to be the first operational airline VTOL.



PRIME EXAMPLE of tilt-wing design is Vertol 76 test vehicle built for the Army.

What price VTOL?

VTOL designs now on the boards may pay off for airlines—after lots more R&D

by Marion O. McKinney, Jr.

Head, VTOL Section, Stability Research Div., Langley Research Center, National Aeronautics & Space Administration*

ONE QUESTION that always comes up in connection with VTOL aircraft is: "How much extra will the VTOL feature cost?" You can get some idea of the right answer by examining three general VTOL types now under development—unloaded-rotor configuration, propeller-powered, and jet-powered configurations.

The unloaded-rotor convertiplane has received much attention over the past few years. A test vehicle, the McDonnell XV-1, has been flown throughout the entire range of operations. It has a helicopter-type rotor driven by pressure jets for use in hovering and low speed flight, and a fixed wing and a pusher propeller for cruising flight. In hovering flight, all the power is applied to the rotor. In cruising flight, all the power is applied to the prop; the rotor autorotates and supplies only about 15 per cent of the lift.

This type is already being developed into an operational transport in England. The Fairey Rotodyne (see *S/A*, "Fairey Rotodyne VTOL Design and Concept," Feb. '59, p. 55), which will seat up to 48 passengers, is evidently intended both as a feeder-line transport to communities without suitable airports for conventional planes and for rapid transportation between city center heliports up to several hundred miles apart.

Some idea of costs might be gained by comparing this design with the Fairchild F-27. The latter has good short-field performance and in size is directly comparable with the Rotodyne. The *Table*, based on data published in trade journals, shows the Rotodyne is slightly heavier and has a lower cruising speed and a shorter range with the same payload.

It's evident that the operating cost of the more complex VTOL aircraft will be greater than that of the

*National Aeronautics & Space Administration, Langley Research Center, Langley Field, Va.



FIGURE 1: Tilt-wing VTOL transport conceived by Hiller.

conventional transport. The advantage of the VTOL must come entirely from the VTOL feature and must offset poorer performance and higher operating cost. Actually, though, except for overwater routes, the Rotodyne-type craft is mainly in competition with surface transportation—over routes for which air transportation now is either not available or not successful.

The tilt-wing-and-propeller VTOL is also receiving considerable attention. Two flight test vehicles of this general type are the Hiller X-18 and the Vertol 76. It has its wing at about 90 deg incidence for takeoff and landing. The wing is rotated slowly to about zero degrees in making the transition to normal forward flight. This craft has already been flown in hovering flight, made vertical takeoffs and landing, and repeatedly gone through the transition from hovering to normal forward flight and back to hovering.

No commercial transport of this type is either flying or under construction. *Figure 1* gives some idea of how such a plane might look. It shows a Hiller design with four large props driven by turbines and auxiliary jet engines at the rear of the fuselage for pitch control in hovering flight.

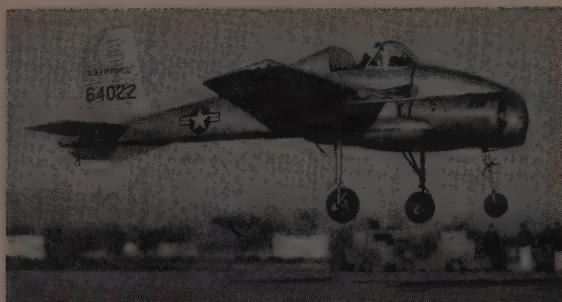
The cost of the VTOL feature for the type shown in *Figure 1* is also given in the *Table*. We can see that the VTOL transport required to carry a payload of 50 passengers plus baggage over 900 nm at a cruising speed of 400 knots is about 25 per cent heavier than, and has twice as much horsepower as, a conventional transport

VTOL vs Conventional Transports

	VTOL	Conventional
Feeder Line Types (Rotodyne vs F-27)		
Gross weight (lb)	39,000	35,700
Cruising speed (knots)	160	230
Range (nm) ¹	260	430
Short Haul Turboprop Types (hypothetical)		
Gross weight (lb)	60,000	47,000
Empty weight (lb)	38,000	27,700
Fuel load (lb)	10,700	8800
Payload (lb) ²	10,500	10,500
Horsepower	16,000	8000
Cruising speed (knots)	400	400
Range (nm, with reserves)	900	900
Supersonic Types (see Fig. 2)		
Payload (lb)	26,000	26,000
Empty weight (lb)	158,000	160,000
Fuel load (lb)	208,000	206,000
Range (nm, no reserve)	3800	3700

(1) With 40 passengers, baggage, and reserve. (2) With 50 passengers and baggage.

more on next page



BELL X-14, an experimental jet-powered VTOL, has gone through its full transition cycle in flight.

designed for exactly the same mission. Clearly the operating cost of the VTOL would be more than that of the conventional transport, because of greater initial and maintenance costs and higher fuel demands.

However, the VTOL can offer considerably faster service between the downtown areas of cities by operating from close-in heliports. This, together with savings in the cost of transportation to and from the airport, may largely offset the VTOL's higher operating cost.

For a transport plane, a horizontal fuselage attitude seems to be essential. A horizontal-attitude jet VTOL test vehicle that has already been flown in both hovering and normal forward flight and has successfully performed the transition between these two is the Bell X-14. It is powered by two Armstrong Siddeley Viper turbojets mounted horizontally in the lower forward part of the fuselage.

The engine exhaust is turned directly downward beneath the CG by means of thrust-diverter vanes to provide the lift for hovering flight. The vanes are rotated to divert the exhaust backward at progressively larger angles during transition, until the craft is wingborne. The exhaust is then directed straight rearward for normal forward flight as a conventional jet. Control in hovering flight is provided by compressed air jets at the wing tips and the tail.

Most of the design studies for jet VTOLs have involved a very long step—right to the supersonic transport. One that has received considerable publicity comes from Rolls-Royce (Fig. 2). With a supersonic transport, the static thrust of the engines needed to propel the plane in the cruise condition is far less than the weight of the craft. Thus it seems desirable to make up the deficiency in thrust with a number of special, lightweight lifting engines arranged along the side of the passenger compartment. These would probably be relatively small, since the best engine specific weight is obtained with fairly small designs. They would probably be turbofan types with a bypass ratio of about 5 to keep the noise and exhaust velocity relatively low. However, the noise and the tremendous energy in the exhaust of so many engines would probably still pose formidable problems.

For an evaluation of this type of VTOL, the two transports shown in Figure 3 were laid out. Both are based on Mach 3 cruise speed, 400,000 lb gross weight, and a payload of 120 passengers plus baggage. The supersonic transport designed for normal takeoff and landing has a wing loading of 65 psf, which will permit landings at the speeds of the current subsonic jet transports; it needs seven engines of a certain size for propulsion in the cruise condition.

The VTOL has 44 lifting engines along the fuselage sides and six propulsion engines in wing tip nacelles. The latter can be tilted to a vertical position for takeoff and landing. Since this design doesn't rely on the wing for landing, wing size could be optimized for supersonic cruise, giving, in this case, a wing loading of 110 psf.

Designs have equal empty weights

The Table also shows estimated characteristics of these two designs. They have essentially the same empty weight, fuel load, and range. That the VTOL design does not have a higher empty weight, in spite of all the lifting engines, may at first seem surprising. The three main reasons for this are: the VTOL has 2500 sq ft less wing area, needs one propulsion engine less, and has a much lighter landing gear. However, since such a landing gear isn't designed for high speed rolling takeoffs and landings, new ground handling procedures will probably be needed before this weight saving can be realized. In any case, the VTOL plane will obviously be more expensive in initial cost and maintenance because of the lifting engines.

In conclusion, we can say that VTOL transports seem to be technically feasible and can have good enough performance to be considered for commercial operation. However, considerable R&D, particularly full-scale flight research, must be done before the airlines can seriously think about such aircraft.

It also seems VTOLs will have higher operating costs than conventional transports. Whether and in what applications they will have the extra usefulness to offset this extra cost is still an open question today.—End

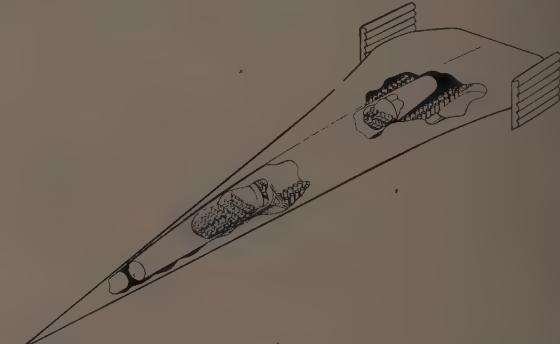


FIGURE 2: Supersonic jet lift VTOL transport as conceived by Rolls-Royce.

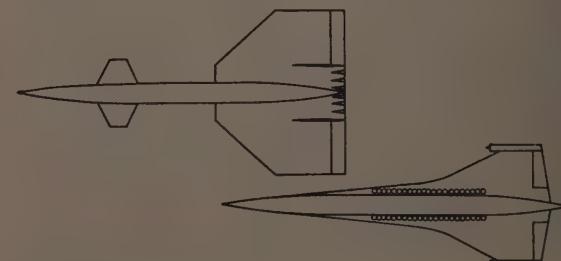


FIGURE 3: Hypothetical comparable Mach 3 designs for VTOL and conventional transports. Both have a gross weight of 400,000 lb and could carry 120 passengers. The VTOL (bottom) has six propulsion and 44 lift engines, the conventional design seven propulsion engines.



HYDRORUPTURED heat-treated cylinder samples failed in a ductile manner after reaching full yield strength of the material. The bottom of each cylinder was supported

by a steel pad during Norris-Thermador test. Left to right: Crucible 56, Tricent, Airsteel X-200, AISI 4340, Crucible 218.

Deep drawing

for high strength solid rocket casings

Propulsion designers are searching for motor case materials which will yield strength to density ratios on the order of 1,000,000. One approach is the deep drawing of H-11 hot work tool steel—something considered impractical a few years ago.

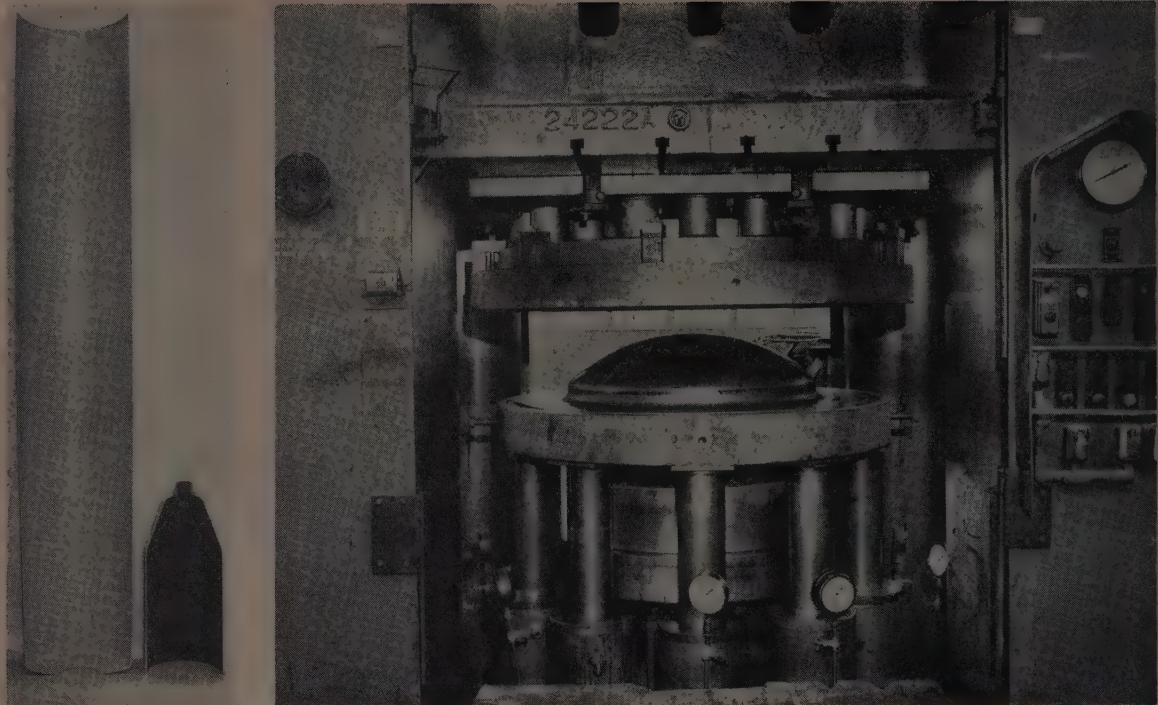
by **Larry Shiller**, Chief Research & Development Engineer, Norris-Thermador Corp.*

NEW MATERIALS and manufacturing techniques are being developed for thin-walled solid propellant motor cases subject to induced stresses of over 200,000 psi. Materials considered impractical for drawing only a few years ago have produced excellent results with current press techniques. As new materials are studied, the drawing process seems more promising than ever for fabricating large vessels of high yield strength.

At Norris-Thermador, we are investigating deep-drawn, hot-work tool steels, particularly the H-11 (5Cr-Mo-V) series, which can be heat-treated to yield strengths as high as 240,000 psi with acceptable ductility. The only apparent size limitations appear to be

* Norris Div., Norris-Thermador Corp., Vernon, Calif.

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MOTOR CASING for Jato unit (center) was the first integrally drawn piece to be put in large scale production. Casing for the Hawk (left) is one of the largest cylinders to be drawn in one piece. Wall dimension was changed from 0.107 to 0.067 in. Right: Six-thousand-ton hydraulic

press used to draw a 54-in.-diameter pressure vessel head of about 0.093 in. thickness. During major reductions in wall thickness, the metal temperatures can go up to 250 deg F. In this setup, the punch is stationary and the die is operated by the press ram.

those imposed by the available width of steel and by press size. Diameters of 100 in. and more are within the realm of possibility. There is no limit on length, since sections can be girth-welded without compromising strength.

Deep-drawn steel rocket motor casings are not new. One of the first in large-scale production was the Navy 15KS 1000 Jato casing. The Falcon missile has a steel motor casing formed as a one-piece, deep-drawn cylinder. The Asp and the Sparrow also have drawn steel motor casings, while the Zuni and the Sidewinder have one-piece aluminum-extruded casings.

Probably the largest single-piece motor casing ever drawn for an operational missile was the one produced for the Army's Hawk. This cylinder has a diameter of 14 in. and a drawn length of 96 in. Halfway down its length, on the inside, there is a step reduction in wall thickness from 0.107 to 0.067 in.

Minimums too high for low-alloy steels

All these missile engine casings were drawn from a low-alloy steel, such as AISI 4130. Yield strength was pushed to a high of 170,000 psi through optimum design and by the use of closely controlled heat treating. Today's minimum requirements of over 200,000 psi are well beyond the capabilities of the low-alloy steels.

The need is for new materials with low weight and high strength. Metals such as Vascojet 1000, Crucible (Halcomb) 218, and Airsteel X-200, which we are

all investigating, fit into this category. They have high strength at both normal and high temperatures, good ductility, and will harden to the strengths demanded by today's designers.

Deep drawing is essentially a cold-working process that "flows" the metal under high pressure into the desired shape. It has several advantages:

- Dimensions and weight can be closely controlled by use of precise punch and die tolerances. Wall thickness can be held to ± 5 per cent.
- Tooling life is exceptionally long. Runs of up to 25,000 and more can be made without exceeding tolerance limits.

• Scale models can be drawn to reproduce the same strain patterns and yield strengths of a full-size casting. Many preliminary designs can be checked out inexpensively before settling on a production design.

The characteristics of the casting material are all-important. The designer must determine the internal pressures that will be produced within the rocket chamber and then select a metal that will provide a yield strength safety factor in excess of service pressure. A "rule of thumb" figure for the yield value of hoop stress in a thin-walled pressure vessel is given by $PD/2t$, where P is internal pressure; D , inside diameter; and t , minimum wall thickness.

Hot-rolled steel is generally used for drawing. It is spheroidize-annealed upon receipt from the mill to change the pearlitic structure created by hot rolling. (Spheroidized steel is more ductile than "as-rolled". It

should be as completely spheroidized as possible for maximum drawability.) A grain size of 5-8 produces good casings. The fine grain prevents surface roughness, known as "orange peeling."

Once a material is picked for possible use, a series of deep-drawn scale models is produced. Both thick- and thin-wall stock tests are made to determine drawability and formability.

In a typical test of H-11 tool steels, the thick-wall sample started out as a disk 3.5 in. in diameter, cut out of a 0.25-in. plate. The final drawn size was 1.5 in. in diameter, with a wall thickness of 0.074 in.

A thin-wall sample 5.125 in. in diameter and 0.060 in. thick was used to test formability. The final drawn size was 1.75 in. in diameter, with a wall thickness of 0.048 in.

Tests were made with Crucible (Halcomb) 218, Crucible 56, Vascojet 1000, Airsteel X-200, Tricent, Super Tricent, Potomac A, AMS 6434, and AISI 4340. After each drawing operation, samples were visually inspected for splits, tears, bad looper patterns, and other defects. Completed model cylinders were then checked inside and out by magnetic particle inspection.

The acceptable cylinders were then heat-treated for maximum yield strength. After that, they were completely instrumented with strain gages for hydronrupture tests to determine the strain characteristics of each model.

Fittings tested on scale models

Scale models of one-third final size were then drawn from the metals which had passed the earlier tests. The one-third scale makes it possible to test attachments, closures, and other fittings that would be on the full-size motor casings. Stock tooling is used for all model drawing operations.

Many test cases 10 in. in diameter by 26 in. in length have been heat-treated to uniaxial yield strengths of 200,-215,000 psi at 0.2 per cent offset. These vessels consistently burst at hoop stress levels in excess of 250,000 psi.

A test program is underway to develop deep-drawn full-scale motor cylinders that will have extremely high mechanical properties. The final casings are to be 35-40 in. in diameter, 70-100 in. in length, and 0.050-0.060 in. in wall thickness.

At present, the design calls for two cylinders girth-welded together to form the completed casing. But preliminary test results indicate this may not be necessary—it looks as though the full length casing may be drawn in one piece.

In general, girth welds are subjected to about one-half the stresses induced in longitudinal welds in the same vessel. Therefore, girth welds are not a critical factor in the yield strength characteristics. One major consideration is to select a steel suitable for welding.

After welding, the casings must be heat-treated to 200,-240,000 psi yield strength. All heating is done in a controlled atmosphere to prevent scaling and decarburization.

Following heating, the tool steel casing is air- or oil-quenched to the desired degree of hardness and then tempered. Fixtures are used during the tempering stage to correct distortions that occur during the heat treatments.

The completed tool steel casing has a Rockwell C hardness of about R_c 45-52. The average elongation in



SMALL-SCALE CYLINDERS formed from test blanks. Thick wall test (left) determines drawability, by reducing the diameter without significantly reducing the wall thickness. Thin-wall tests prove out formability by reducing both diameter and wall thickness.

Mechanical Properties of Deep-Drawn High Strength Steels

	Mechanical Properties		
	Formability	Elongation (per cent @ highest yield in 2-in. gage)	Yield strength after temperature (psi)
Vascojet 1000	good	5%-6%	230,000
Airsteel X-200	good	7%-8%	235,000
Crucible 218	good	6%-7%	230,000
Crucible 56	good	5.5%-7%	240,000
Potomac A	good	7½%-8½%	240,000
Tricent	fair	*	*
Super Tricent	poor	*	*
AISI 6434	good	6%-7%	210,000
AISI 4130	good	7%-8%	190,000
AISI 4340	good	6%-7%	225,000

*Data not available because drawing tests were not carried to completion.

two-inch gage is approximately five to ten per cent.

One of the major reliability advantages of deep drawing is that rejects are exposed during the process, because of the high level of stress imposed on the steel during the drawing operations. Any material defect shows up as a metal failure during the early stages.

High-carbon, high-chrome punches and dies are used for short run production. For long runs, the dies are made of tungsten carbide for better wear resistance. A hard-chrome plating also gives punches a longer life by cutting down the wear. When wear limits are reached, the tool can be stripped and replated at little cost.—End

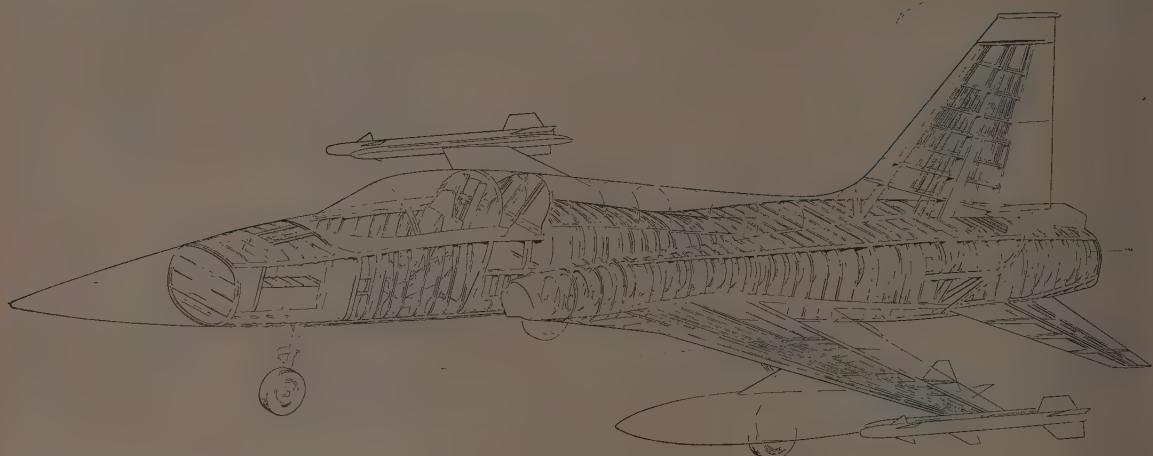


FIGURE 1: Structure of Northrop N-156F fighter, designed to meet needs of free-world nations. Complete

wing and landing gear are assembled as one unit, then attached to fuselage with six bolts.

Overall capability

is key to N-156F design

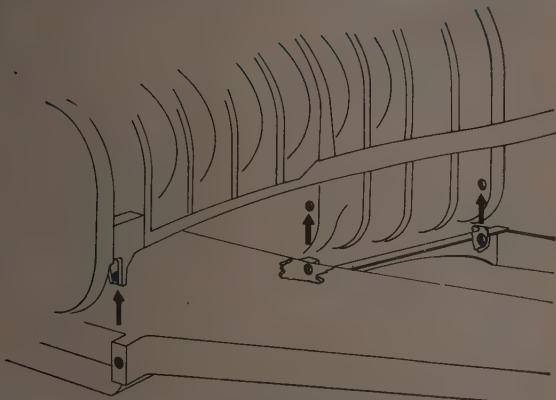
There's no better example of the close connection between all forms of airborne designs than Northrop's N-156F "counter-air" fighter—it was feedback from the development of small, efficient jet engines for missiles that made possible the design of a new family of versatile, lightweight manned aircraft.

by Irwin Stambler, Associate Editor

THE ROLLOUT of the Northrop N-156F multi-purpose fighter this month and the simultaneous first flights of the earlier T-38 trainer mark a new concept in manned aircraft design. As Northrop engineers told SPACE/AERONAUTICS, the common basic design of these two planes puts the emphasis not on one or two factors—such as top speed or altitude—but strictly on overall capability.

Another novelty about the N-156F is that it's the first plane designed by a U.S. firm to the needs and capabilities of the NATO and SEATO countries and our other allies, who will eventually use the Northrop design as a first-line fighter. Most N-156F production will be done overseas by our allies themselves. Northrop will supply tooling and technical assistance.

Northrop's basic idea of a small, lightweight supersonic fighter that would perform "counterair", or intercept and bombing, missions usually requiring much heavier and complex craft became feasible, company engi-



WING-FUSELAGE attach (left) and mockup of N-156F. Horizontal tail and aft fuselage assembly can be removed



for maintenance without removing the fin. Arrow points to wing root extension for better V_{MAX} .

neers note, after two advances in the state of the art:

- the development, originally for missile use, of small, high performance engines—as Welko Gasich, director of weapons system development engineering at Northrop's Norair Div., Hawthorne, Calif., points out, this made it possible to take advantage of the "3/2 rule," which states that thrust varies as any linear dimension squared and weight varies as the length cubed (so that the thrust-weight ratios of large engines are not as good as those of small ones);

- NACA's discovery of the area rule.

Possible configurations were considered in terms of "total force effectiveness" (TFE), the product of performance of each unit, number of units, and combat readiness. For maximum unit performance, Norair engineers claim, costs would have to go up and the number of units would go down. Their studies also indicated that top speed bought very little in terms of intercept time. The approach they finally took in the N-156F design, they believe, enabled them to come up with a plane with an overall combat capability greatly superior to that of current production fighters for use against air and ground targets—at half to one-third less cost per unit.

Top speed will be near Mach 2

The N-156F has some changes from the T-38. The trainer was designed for long endurance, and the minimum top speed it had to attain was Mach 1.1. Its top speed reportedly is about Mach 1.38. The N-156F is to have a top speed of about Mach 2 when it reaches operational status.

As one of the results of about 6000 hours of wind tunnel testing on both planes, a wing root leading edge extension was added on the N-156F to help increase the top speed. In another move to optimize the fighter design for high speed, the fuselage area distribution was changed slightly.

As designers point out, getting the proper amount of Coke bottling can be a problem. It calls for minimum

fuselage section at the maximum point on the wing. So when the plane is first laid out, the designers must take a stab at the weight distribution to locate the wing. Then the fuselage is Coke-bottled for good transonic performance. However, as the N-156F design progressed, changes in actual weight distribution (as shown by balance checks) made it necessary to relocate the wing at least four times.

Norair engineers believe the N-156F has the narrowest spec cockpit of any supersonic fighter—only 40 $\frac{3}{4}$ in. from mold line to mold line. Yet, they say, while smaller on the outside, the N-156F is bigger on the inside. A 30-in. cockpit rail width leaves plenty of room even for a pilot wearing a pressure suit.

The wing leading edge has been changed to take a flap with a maximum of 25 deg deflection for better takeoff performance. The trainer can take off from 6000-8000 ft runways, but the fighter must operate from fields as short as 3000 ft. It has, in fact, been designed to permit zero-length launching.

A major part of Northrop's wind tunnel work was devoted to developing a good supersonic wing for the two planes. Particular emphasis was placed on subsonic airfoil performance, on which not much information was available. The addition of leading edge camber, engineers say, has provided a design with good subsonic cruise capabilities but still thin enough for high Mach numbers. The basic wing section is cambered from the 40 per cent point forward.

The N-156F was also designed with a C_{M0} of zero degrees for zero C_L , so that at high speed, the pitching moment of the fuselage would balance the down-load of the tail. This effect only holds at one speed condition—in this case selected as V_{max} , since minimum drag is desired at this point. As trim drag gets to be a considerable part of the drag problem at this velocity, this approach made it unnecessary to go to canard controls. However, it did cause some inlet and stall problems. Eliminating the S-shape also helped improve performance at V_{max} , engineers note.

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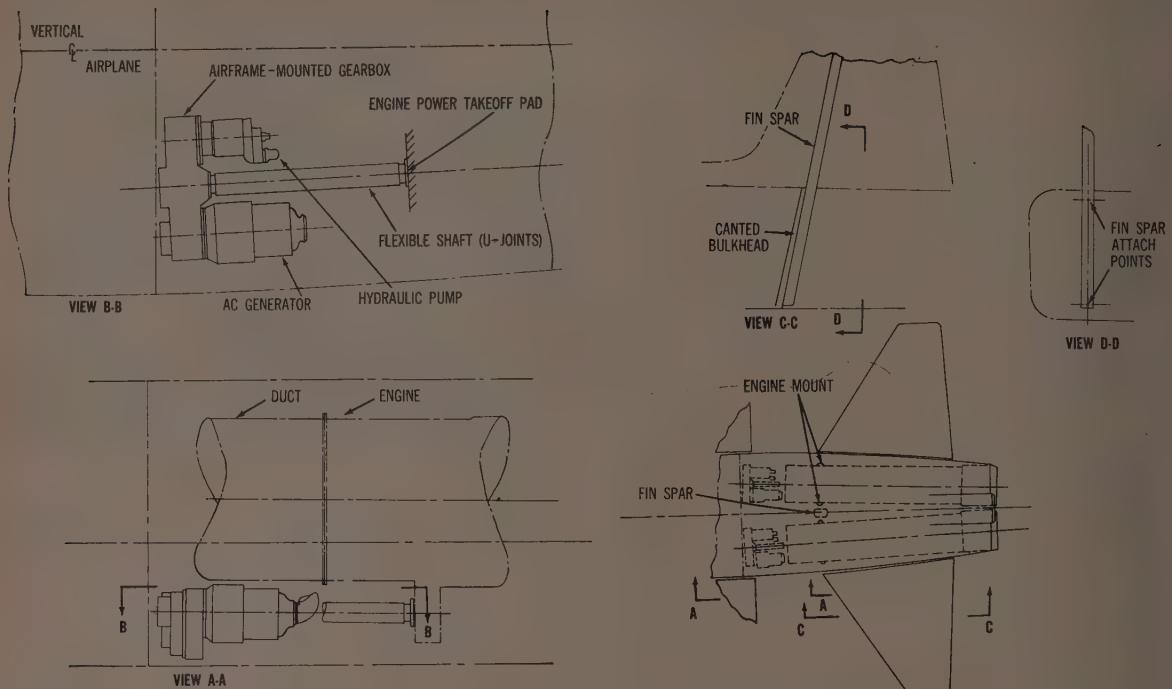


FIGURE 2: Engine installation, showing simple, rugged attachment of the fin spar and accessory-to-engine jacks-

haft arrangement. Two GE J85 engines will be used, though the plane could also take J60s or R-R RB-145s.

A major problem when two engines are installed side by side is the V-shaped area between their exhausts, which causes base drag. If the engines aren't close enough together, base plates must be used (Fig. 4). They are made of steel and, in addition to costing weight, generally cause problems throughout the design.

On the N-156F, the engine exhausts were moved together as close as possible to eliminate the plates. Cooling air is ducted through holes in the corners of the tail. There's also a slight air bleed all around each tailpipe.

Slanting the engines outboard provided a number of advantages. For instance, it gave an almost straight duct setup from the inlet face to the compressor. This, Norair states, contributes to the lack of distortion of the air entering the engine, improving the engine compressor stall margin.

Variable inlet geometry was not needed for the trainer because of its modest supersonic speed. The faster N-156F will probably have some form of variable inlet geometry.

The fuel system is simple

The engine installation permits a simple, rugged attachment of the fin spar (Fig. 2). It also eliminates fuel storage over the engines or aft of the compressor face—at least with small engines, Norair points out, whose excellent sfc cuts down on the total fuel requirement.

As Figure 3 shows, the fuel system is very simple. It consists essentially of two separate systems and requires only two pumps and three valves, one of which is a cross-feed. The two systems are completely separate un-

less a pump fails, in which case the cross-feed can be opened. Even if both pumps fail, the plane can still be flown on gravity feed, engineers say.

No sequencing is needed for CG control. Single-point refueling is used (manual, if desired), and there are provisions for in-flight refueling. Two drop tanks can be mounted about 60 per cent outboard of the semispan.

The structure is essentially a conventional built-up type (Fig. 1) of 75ST aluminum. Honeycomb is used in the outer ends of the wings, the flaps, and the control sections. Because of limited data on honeycomb, the primary structure was designed to take the limit load (with some deformation) in case of failure of any honeycomb part.

The fuselage breaks down into three main sections: main fuselage, horizontal tail, and wing. The wing is assembled as a single, complete span (except for the tips), so that it can be attached to the fuselage with the landing gear already installed.

The tail break represents an unusual approach. Northrop experience indicated that assembling an aft section including the fin under high wind conditions is a difficult chore, because of the weight of the assembly and other factors. As a result, in the N-156F only the horizontal tail comes off. This has also provided a simpler design, since mechanics don't have to unfasten fuel vent lines, rudder control cables, wiring, etc.

Simple maintenance was naturally another aim in the N-156F design. The horizontal tailplane was placed about 2-5 per cent of the MAC below the chord plane of the wing to eliminate pitch-up. This gave an essentially flat underbody from 30 per cent of the wing chord

on back, permitting good access to the landing gear doors and other equipment.

The location of the tailplane and the engine arrangement also enabled Norair to run the control tunnel in a straight line from cockpit to horizontal tail, which again made for easy installation and access. It also makes it possible to pull off control cables with a minimum number of pulleys, reducing breakout friction and providing the pilot with smooth transition at the neutral point. Black boxes have been located in the nose, so that work on them can be done by a man standing on the ground.

The windshield is hinged forward

Another innovation is that the main windshield is hinged forward. On the F-89, either the windshield or the side panel has to be completely removed by a mechanic who wants to work in the cockpit area. Since this is a pressurized area, the plane must be grounded until an inspector rechecks the cabin pressure after the panel has been reinstalled. On the N-156F, the alignment of the windshield isn't disturbed, and no rechecking is necessary.

Another design innovation has separated the problem of accessory maintenance from that of engine maintenance. Accessories are airframe-mounted and driven from a power takeoff consisting of a single jackshaft that is also mounted on the airframe. This shaft splines into a mating part on the engine. The engine rolls out on a small track, automatically disengaging itself from the jackshaft, which remains on the airframe. Through an access door under the accessory gearbox, the accessory unit can be taken out without disturbing the engine.

The accessory design itself is interesting. Conventionally it would have involved a constant-speed transmission. However, Norair found that almost 95 per cent of the electric load could accept 320-480 cycles. To operate in this range, it was necessary to go to an automatic-shift, two-speed transmission.

The two-speed gearbox is lighter

The two-speed system was designed by Waste King's Technical Products Div. to Northrop specs. At engine idling speed of 48 per cent rpm, the generator comes in the line with a frequency of 320 cycles. As the throttle is advanced, this value goes to 480 cycles at about 67 per cent rpm. Then a mechanical governor shifts the transmission back to 320 cycles, from which the frequency goes up to 480 cycles at 100 per cent rpm. A dead band in the governor of about three per cent at the 67 per cent rpm point provides leeway for shifting.

This design, Norair reports, has turned out to be lighter than a constant-speed one and has shown excellent reliability so far. Since the plane needs a small amount of closely regulated 400-cycle current for its instruments, a static inverter system is provided. The energy loss in the transmission is so low that the unit can be cooled simply by fins.

A hydraulic pump is mounted on the gear box and is driven through the same transmission. This provides a high rate of hydraulic flow at landing or flare-out, permitting the use of full-powered controls. In addition to the flight control hydraulic system, there is a utility hydraulic system to supply power for speed brakes and landing gear as well as half the power for the flight control.

The flight control system operates off the right-hand

engine and the utility off the left-hand one. Preloads eliminate control surface backlash. If an engine or pump goes out, half hinge moment is still supplied to the controls.

Norair emphasizes that the N-156F is a lightweight fighter, and not a stripped design. The craft is designed to take a wide range of systems, from relatively simple electronic gear up to the most sophisticated fire control and armament equipment. It has all-weather capability for both air-to-air and air-to-ground missions. To get more versatility, it was decided to have all armament mounted externally. Northrop reports that 48 different combinations could be carried.

The N-156F has a take-off weight of 12,235 lb, a maximum range of 2000 nm, an overall length of 43 ft 11 in., a wing span of 26 ft 5 in. (with wingtip armament), and a height over tail of 13 ft. While there have been some problems with the GE J85 engines slated for the craft, it's stated that these have been overcome and won't affect the N-156F schedule. The plane can also take such alternate powerplants as the P&WA JT-12 (J60) and the Rolls-Royce RB-145.—End



COMPARISON of N-156F and T-38 side views shows some of the differences between the two planes.

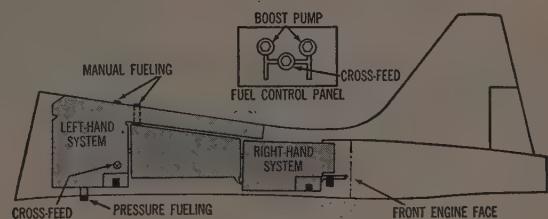


FIGURE 3: N-156F fuel system. All tanks are located in air duct areas ahead of engine.

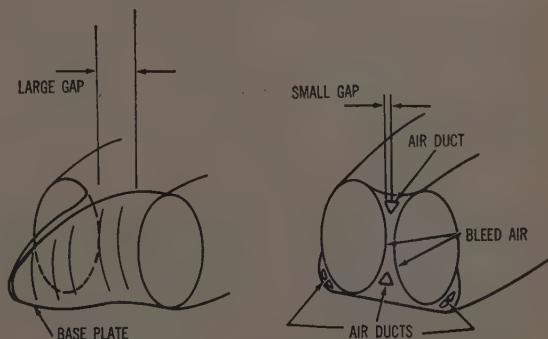
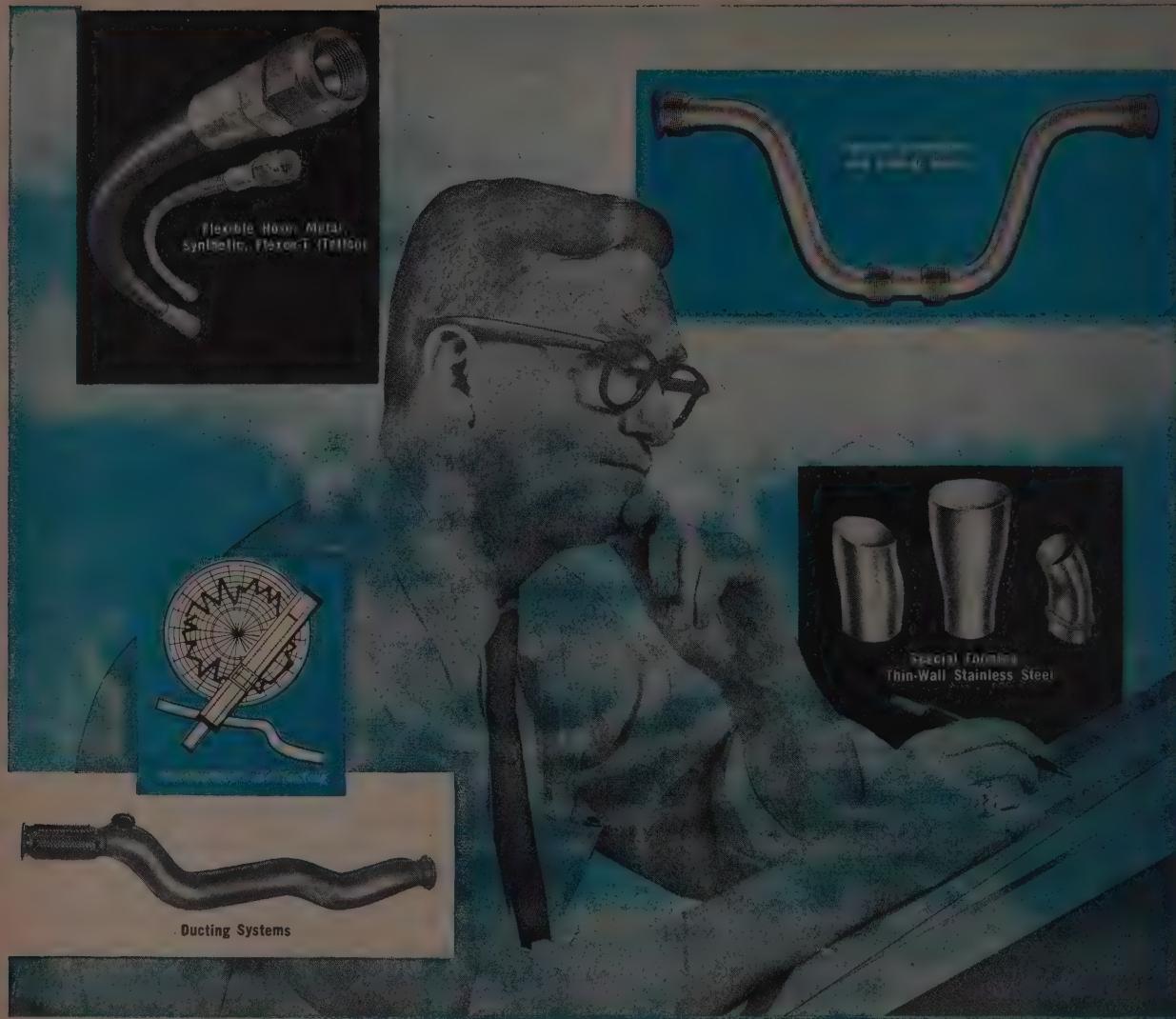
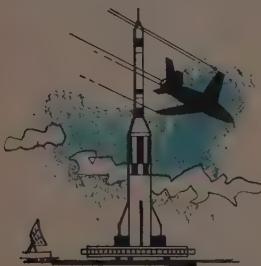


FIGURE 4: Two-engine installation can require use of heavy steel base plates (left). N-156F design, by mounting engines in V-pattern, eliminates base plates (right). Note how N-156F cooling air ducts are installed in limited space.



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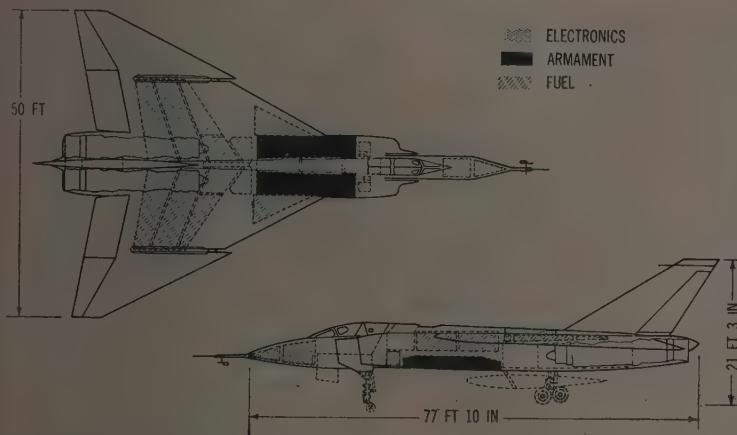
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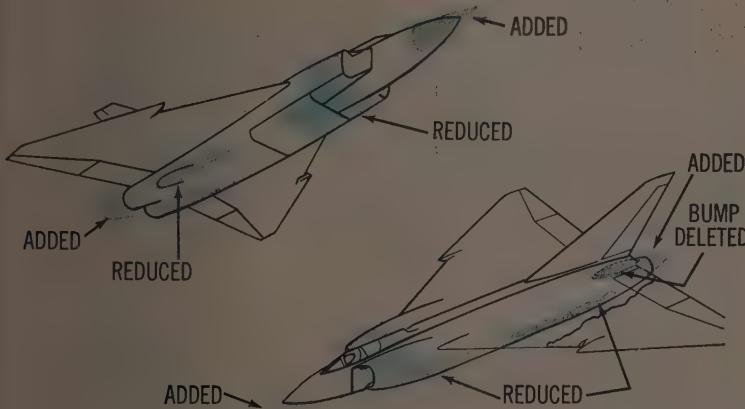
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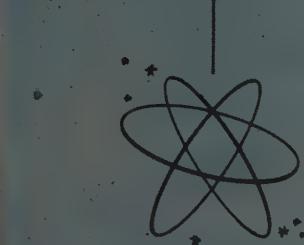


CONFIGURATION was dictated mainly by cockpit, powerplant, and weapon payload. Wing area is 1225 sq ft. With a normal combat gross weight of 64,000 lb, airborne takeoff speed is about 170 knots at an altitude of about 11 deg. Touchdown speed is a bit over 165 knots.



EXTENSIVE AREA RULE study resulted in many modifications. During the preliminary design, Avro sharpened the radar nose, cut down the thickness of the intake lips, reduced the cross-section of the fuselage below the canopy and in the aft section, and added an extension fairing at the rear to smooth out the bumps in the area rule curve.

design progress



by **Victor DeBiasi**
Associate Editor

Avro Arrow: New frontiers of fighter design

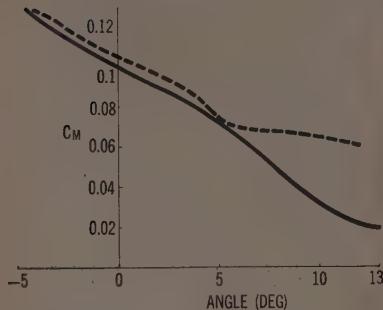
AVRO's CF-105 ARROW was designed from scratch to meet interceptor requirements no other plane could meet: supersonic speed, all-weather capability, unusually long range, fully automatic fire control, above-average kill probability on the first pass. With an installed thrust well over twice the CF-100's 7000 lb plus, the Arrow is known to have flown over 1000 mph at 50,000 ft in a climb while still accelerating during its first month of flight tests in early 1958. From the start, the CF-105 was designed to have a fully integrated electronics system. This included automatic equipment for flight control and stability damping; radar target detection and acquisition; attack approach, intercept, and breakaway; optimum range and angle missile launching; telecommunications; and navigation. With two men it would have been possible to carry out missions in fully or semi-automatic, or manual modes.

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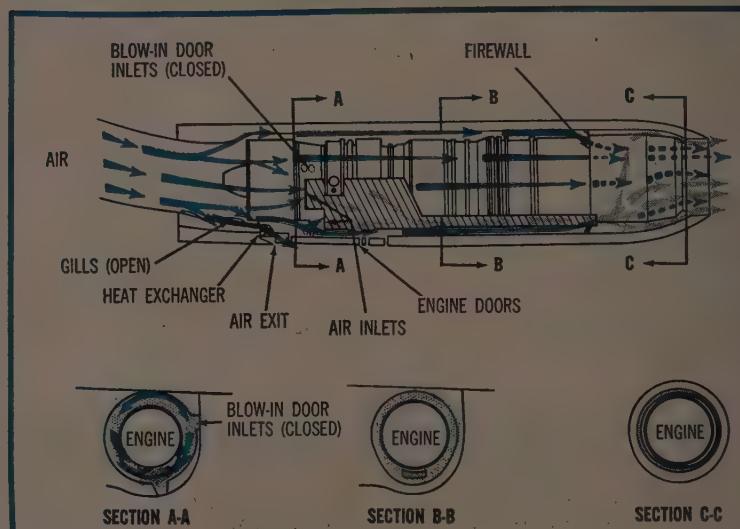
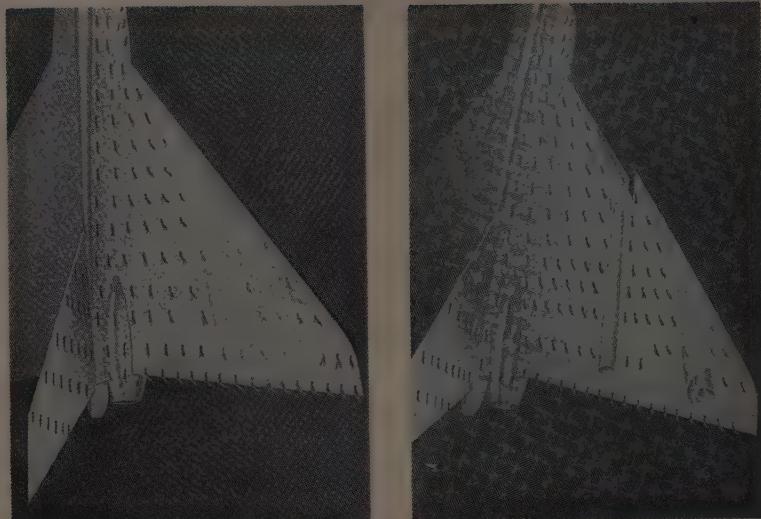
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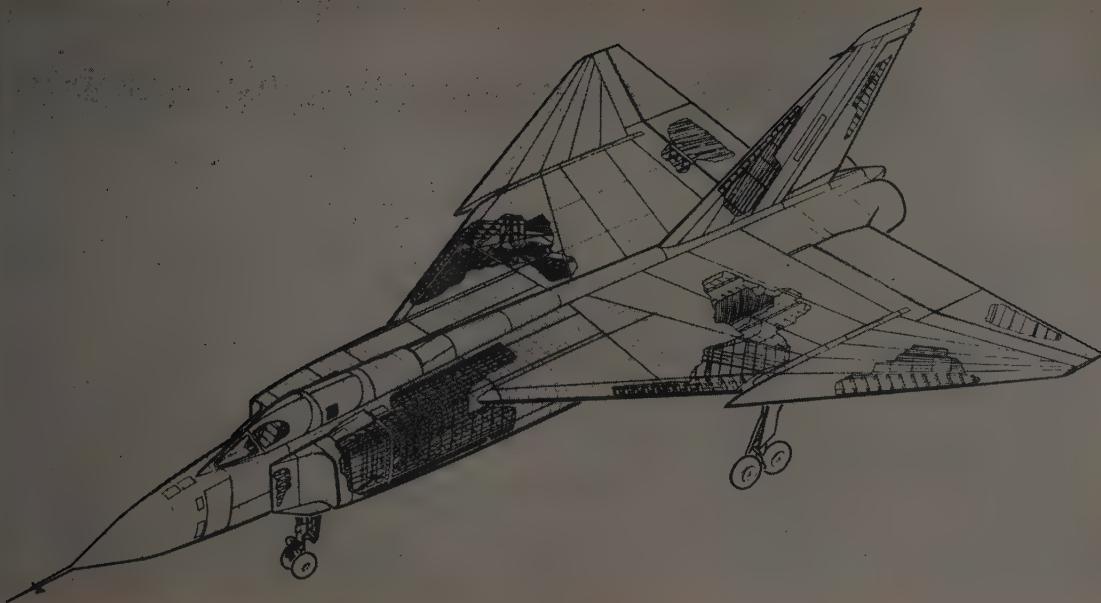
ARMAMENT PACK is designed for fast replacement. Several different missile weapon packs can be used interchangeably. The pack is lifted into place by a self-hoisting mobile support carriage (which also serves as a transport dolly) and is secured flush with the underside of the fuselage at four connection points. Estimated size of armament bay is 16x9x2½ ft. Arrows show hoist point.



ORIGINAL WING (near right) was plain. Wind tunnel tests on a sting-mounted three per cent complete model revealed a pitch-up condition at moderate angles of attack. The air flow would break away outboard of the area covered by the vortex envelope. This caused the effective aerodynamic center to shift forward and produced an abrupt change in the moment curve. Modifications helped make the moment curve more linear. Plot is for the modified wing (solid curve) vs the original plain wing at Mach 0.9 and an elevator angle of -20 deg. Droop of eight degrees inboard and about four degrees outboard helped extend the buffet boundary considerably. At normal subsonic cruise of Mach 0.925, C_L for buffet onset is increased from 0.26, with a leading edge extension alone, to 0.41 with the extension and the plus droop. Modified wing (far right) has both a five per cent notch about midspan and a 10 per cent increase in the outboard leading edge as a cure for pitch-up. Notch helps prevent flow separation and reduces the area of disturbed flow over the wing. Eight different notches and three extended leading edge combinations were tried. The depth of the notch proved to be the most critical parameter.



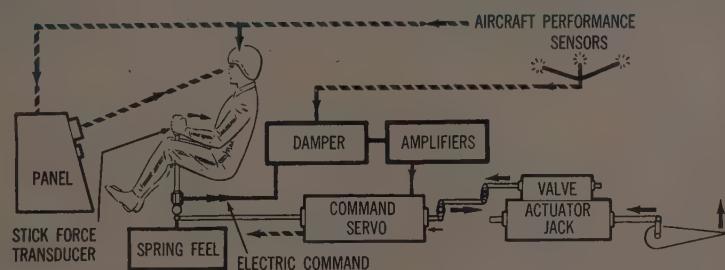
CF-105 was to be powered by two Orenda Iroquois engines with integral after-burners. Over Mach 0.5, ram air opens intake gills near compressor to bypass cooling air around engine. This also reduces spillage at high speeds. Result is near-optimum performance at all speeds despite fixed geometry intake.



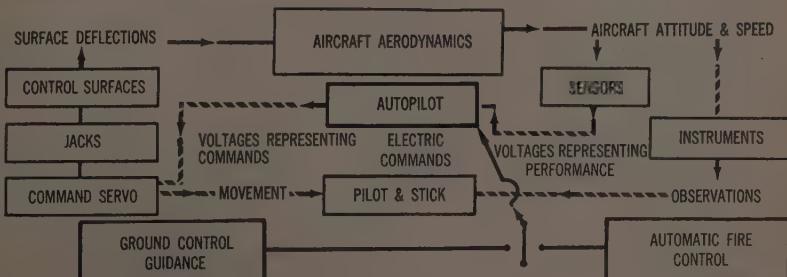
WING DESIGN started out with a three per cent T/C ratio throughout the spar. Aileron reversal forced compromise of 3.5 per cent at the wing root and 3.8 per cent at the tip. Negative wing camber of $\frac{3}{4}$ per cent was chosen to avoid excessive trim drag otherwise needed at high altitudes. Inner wings are joined at the center line of the aircraft. Outer wings are attached by a peripheral bolted joint. Inner wing consists of a main torsion box made up of four 75ST6 spars with ribs running parallel to the plane's centerline and 75ST6 machined skins with integral stiffeners connected by posts. Main torsion box also acts as an integral fuel tank pressurized to 19 psi. Fin has a four per cent T/C ratio. Structure consists of

a multi-spar box beam with heavy, tapered 75ST6 skins and ribs normal to the spars. Fin is attached directly to a box section aft of the main torsion box. Outer wing consists of a multi-spar box beam with heavy 75ST6 tapered skins and ribs running normal to the main spars. Trailing edge control box houses the aileron control linkage system to which the control surface is attached by a continuous piano hinge. Structural materials are mostly aluminum alloy. Inner wing skins are machined from a solid billet stretched a nominal two per cent immediately after solution treatment and before artificial aging. New 7079 aluminum alloy was used for parts machined from hand forgings for sections up to six inches thick.

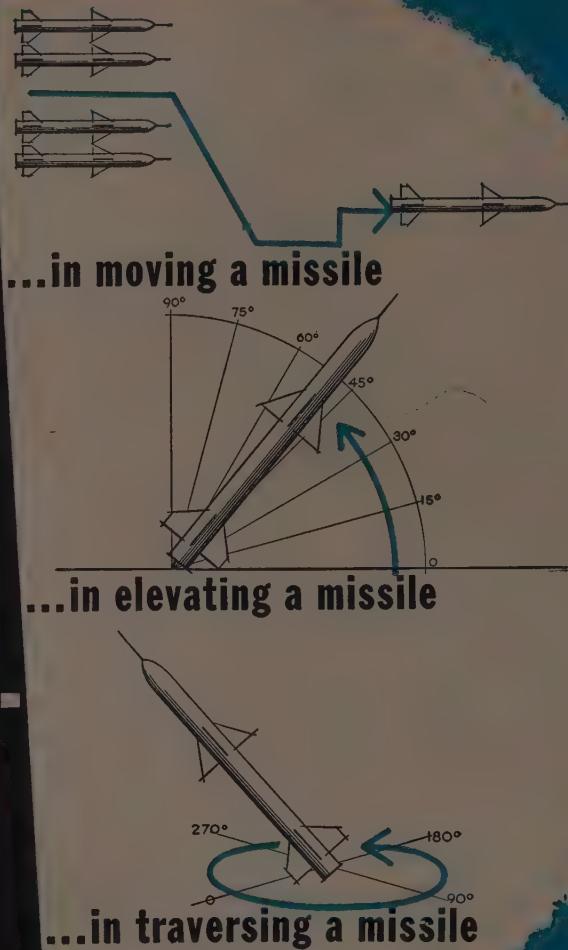
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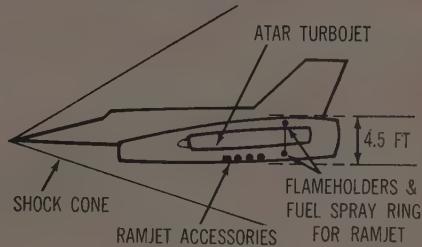
SPACE/AERONAUTICS



FIGURE 1: Nord Griffon II and SPACE/AERONAUTICS' conception of its turbo-ramjet installation.

Turbo-ramjets

... best for Mach 2-3?



Are bigger and better turbojets, with all their weight, complexity, and high cost, the inevitable powerplants for flight at Mach 2-3? No, say the French, who have come up with what looks like a perfectly feasible combination of turbojet and ramjet that's simple and cheap and gives startlingly good performance.

by Denis Desoutter, Foreign Corresponding Editor

A COMBINATION turbojet-ramjet may turn out to be the best powerplant for Mach 2-3 aircraft—if the promise of recent flight tests of the French Griffon (Griffon) II holds up. New performance data on such an engine and details on the theory behind it were revealed a few weeks ago by General Noël Daum, technical director of Nord Aviation, 12b Av. Bosquet, Paris 7, France, when he delivered

the Twelfth Bleriot Memorial Lecture before the Royal Aeronautical Society in London.

Nord started the Griffon project as a research study on supersonic propulsion. The model 'II', using a turbo-ramjet, made its first flight in January 1957. Before the end of 1957, flights at Mach 2 had become routine. By now, the Griffon II has made some 200 flights and reached Mach 2.1 at 60,000 ft.

Several pilots not connected with Nord have flown the Griffon II and commented on its smoothness in comparison with planes using jets with afterburners. They were especially impressed with the high G that can be pulled at supersonic speed.

Contrary to what one might expect, the Griffon's ramjet is insensitive to the incidence at the intake, which lies within the Mach cone of the plane's nose, and so very high thrust can be held in turns. This ability was strikingly demonstrated when the Griffon II set a new 100-km closed-circuit record of 1638 km/hr, far surpassing the previous record of 1171 km/hr (held by a Douglas Skyray).

All this has been achieved with a propulsion system built around a single Turboméca Atar 101-E3 turbojet with a sea level static thrust of 7700 lb. This jet is mounted centrally in a ramjet duct

more on next page

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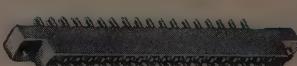
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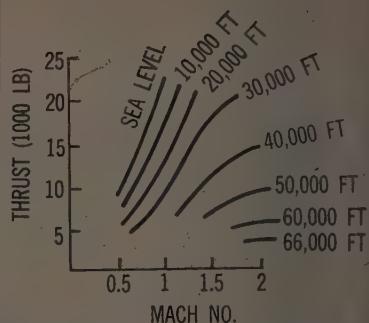


FIGURE 2: Thrust of turbo-ramjet in Griffon II.

(Fig. 1). The flameholders for the ramjet are at a point about 70 per cent back along the outer shell of the turbojet.

Turbojet is shut off at high cruise speed

The 101-E13 model of the Atar is not a supersonic engine, yet it is just what the Griffon II was designed for. The plane's ramjet and turbojet share a common intake and a common exhaust. With such a configuration, the turbojet's environment at all times is subsonic. The flow speed at the intake as well as the exhaust of the turbojet is around Mach 0.4-0.5. At high cruise speed, the turbojet can be shut off and left to windmill slowly, keeping up the pressure in the plumbing.

By burying the turbojet, Nord has made it independent of any change in aircraft angle of attack. The modified air flow within the ramjet duct also makes it easier to restart the turbojet in flight.

The combination turbo-ramjet shows very high thrust at high altitude—even at Mach 2 there is considerable excess thrust, which could provide even higher speeds (not in the Griffon II, though, which is limited by kinetic heating). At 60,000 ft, for example, the thrust is 5500 lb, while at 50,000 ft it is 9200 lb (Fig. 2).

High thrusts at very low installed weights

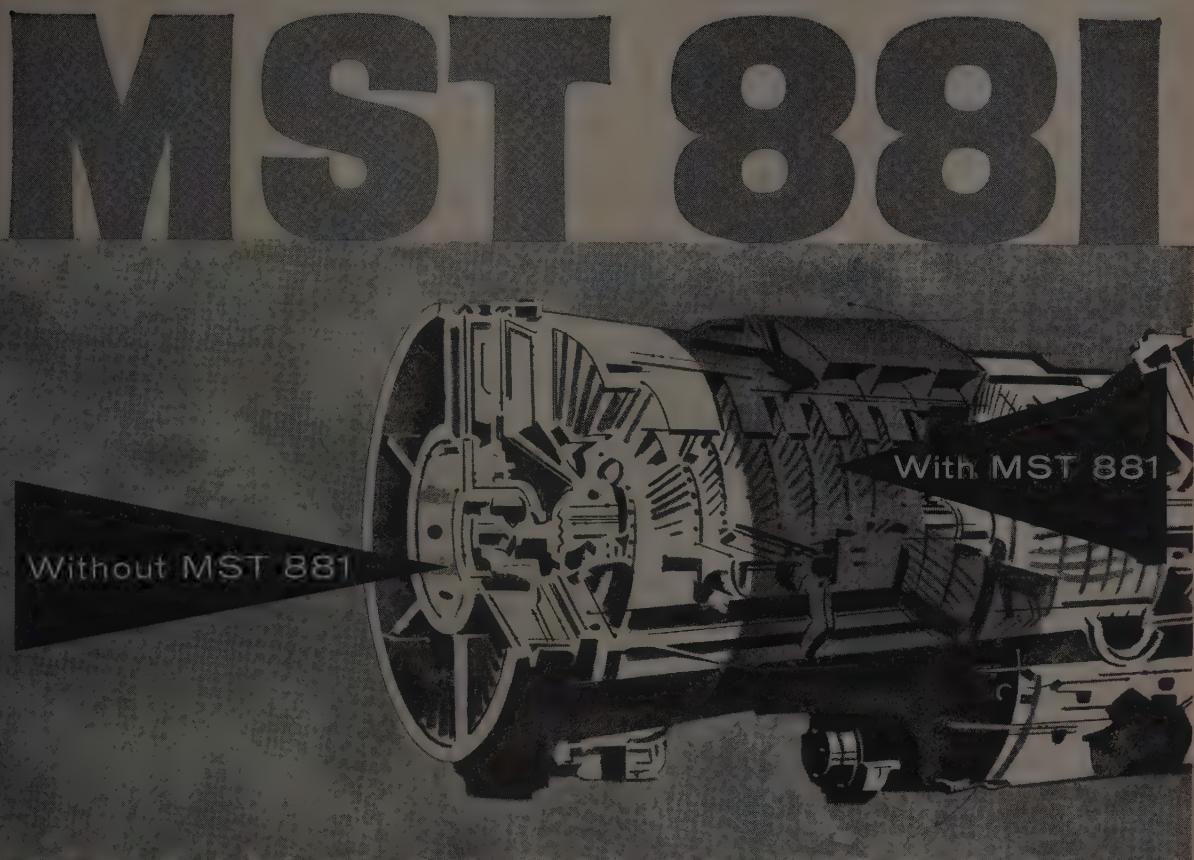
These high thrusts are achieved at a very low installed weight. The whole Griffon II propulsion system weighs 3740 lb, including all the ramjet accessories and the aft part of the fuselage forming the 4.5-ft-

more on page 66

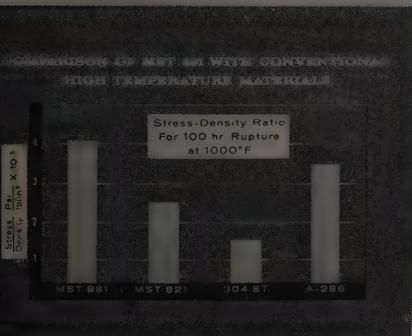
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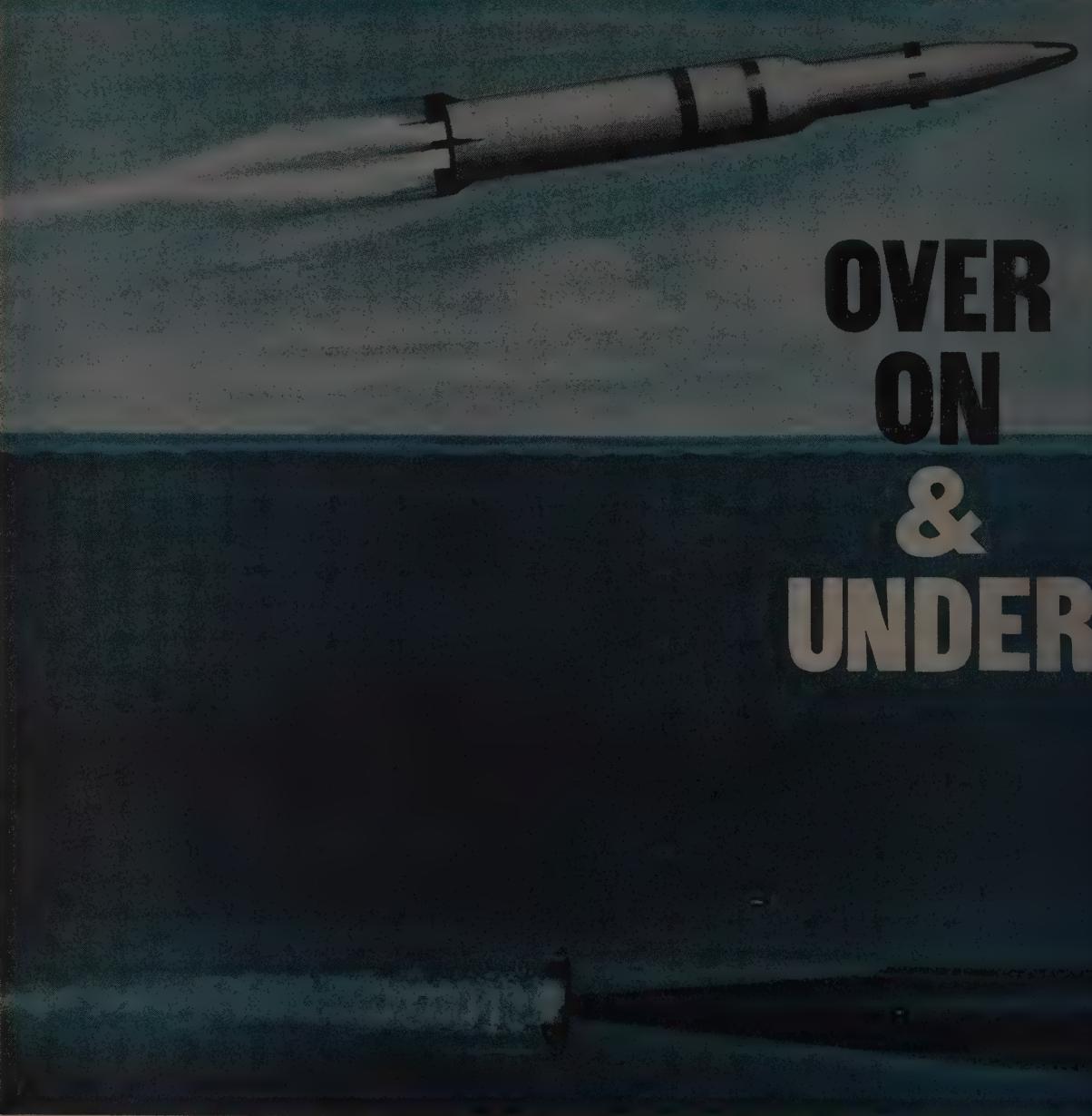
Studies are also being carried out on application of MST 881 in the landing apparatus of manned skip-glide vehicles, in high temperature gears, machine gun poppet valves, and steam turbines operating at 1000° F.

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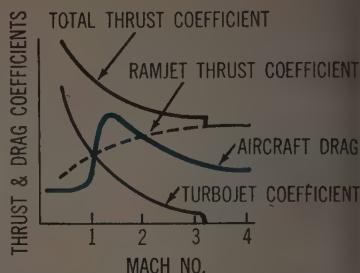
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diameter outer shell of the ramjet. The Nord turbo-ramjet not only looks simple, it really is simple—the intake is a constant-geometry pitot type, and the exhaust, too, has a constant geometry. The trick behind this surprising design is based on the fact that a turbojet and a ramjet depend, respectively, on the Mach numbers at the front of the compressor and of the combustion zone. Because of these complemen-

tary characteristics, explains Gen. Daum, you can always find an efficient fixed intake that will allow acceptable matching of the total air flow over a wide speed range (assuming, of course, the two jets share a common inlet and exhaust).

The total air flow coefficient of a turbo-ramjet with fixed geometry at both ends varies much less than that of either a turbojet or a ramjet used by itself. Matching remains



THRUST coefficients of the Griffon II propulsion system.

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At first glance, what the combination of the two types of engines seems to make possible is the addition of the two thrust coefficients for any desired variation with speed. But that's not all, Gen. Daum points out: "We may expect not only the sum of the thrust of a turbojet and that of a ramjet, but the sum of the thrust of a turbojet without intake losses and that of a well-matched ramjet . . ."

Nord also points out that, besides being simple and cheap in construction (since it uses only a low-powered, subsonic turbojet), its combination powerplant also gives good specific fuel consumption. The company has a developmental model of the Griffon underway, of which it predicts "with confidence" that it will reach Mach 3 between 66,000 and 80,000 ft and have "a hitherto unapproached degree of maneuverability at very high altitude."—End

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ENGINEERING NEWS

ILLUMINATING ANSWERS FOR COMPUTER PROBLEMS

A newcomer to the Hetherington indicator light line is this low-cost series for analog and digital read-out devices, computers, and a host of precision instruments. Dubbed the "Digicator" series, these subminiature lights provide an attractive, easily-mounted display of numerals, letters or symbols in minimum space.

Figures engraved on black plastic lenses are boldly illuminated by midget flange-base AN3140-type incandescent or neon lamps. Serrated spring metal fingers snap lenses and lamps into positive contact—yet allow lenses to be freely rotated to position the figures. A slight pull removes both lens and lamp in one operation for quick, front-of-panel lamp replacement.

Digicator light sockets are available individually, in strips, or as special assemblies to meet individual requirements. To allow lights to be grouped

closely together, the usual mounting nut and lock-washer have been replaced with an integral collar which is flared to the mounting surface—like an eyelet—using an inexpensive flaring tool and anvil.

Special patch cord plugs are available to convert any group of Hetherington Digicator sockets into a complete, low-cost program board. Simply by substituting patch cords for desired lens and lamp assemblies in a read-out panel, for instance, electrical signals can by-pass the visual stage and feed other equipment directly.

Full details on the entire Digicator line are shown in Hetherington's new four-page Data Bulletin L-4—available upon request.

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Ordinary "earth-loving amps" are fairly well behaved and reasonably predictable. Put them on a plane, however, and it's a different story. Combinations of altitude, humidity, and cramped quarters make them a bit tipsy and rambunctious—often setting off heated battles with nearby components.

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The entire Hetherington W100 Series includes six different contact arrangements and three button styles. There's also a choice of eight plain- or color-anodized aluminum mounting adapters—including MS25089 types A thru E. Dimensions and full specifications are shown in Bulletin S-2.

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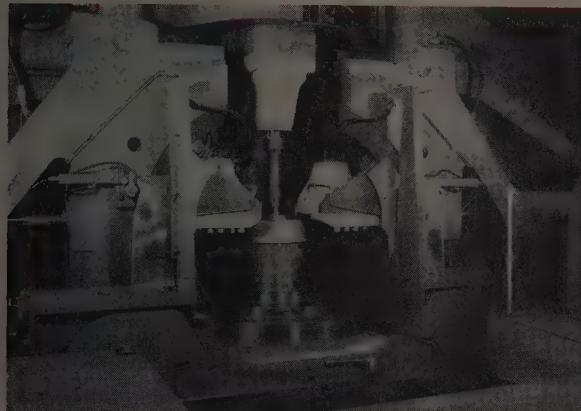
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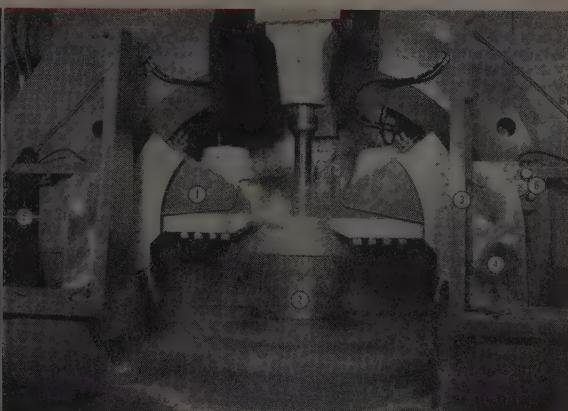
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IN SPIN FORGING, the angular position of the roller heads (1) can be controlled throughout the forming cycle. Driven by a hydraulic motor, the spindle (2) provides smooth speed changes over an infinitely vari-



able range. The holders (3) of the cam templates (4) allow micrometer adjustment in two axes. Other parts: cross-slide actuating cylinder (5) and tracer finger (6). Direction of roller movement is toward observer.

Faster forming of complex parts by spin forging

Previously impossible one-piece fabrication of complex hard metal parts is the main claim made for Hufford's novel spin forging process. On top of that, the strength of the material is increased by 100 per cent, it is reported.

by Randolph Hawthorne, Editor

SPIN forging combines metal spinning and roll forging principles in a single shearing, spinning operation. By this process, hollow cones, cylinders and hemispheres with tapered skin and integral reinforcing sections, and parts of revolution can be produced accurately

and with an attractive saving in material.

These parts can be made seamless from a single piece of material. The process therefore is suited to aircraft, missile, and powerplant components. Hardware, essentially "sheet metal" by nature, can be

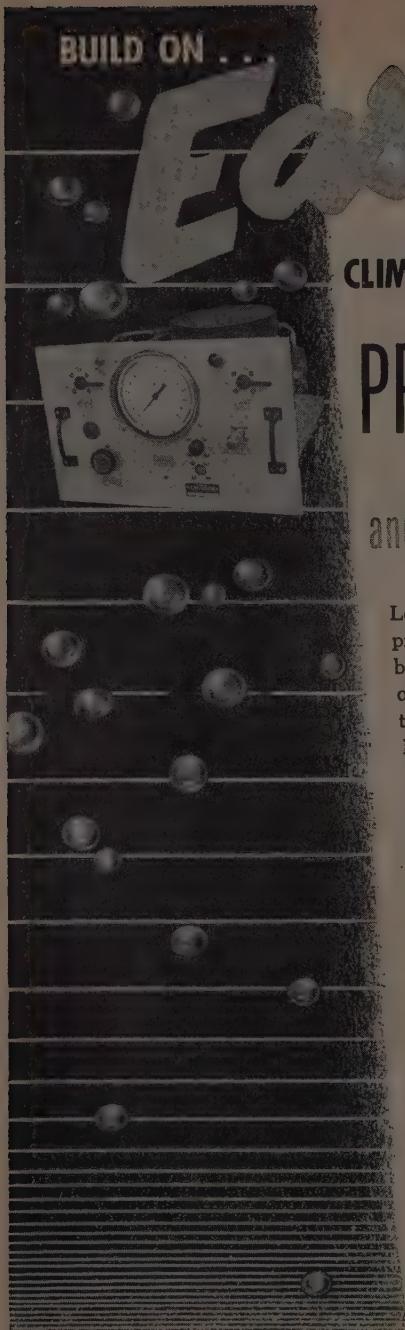
fabricated with dimensional tolerances and surface finishes normally achieved only in machine tool cutting operations.

The process resembles spinning in that the work piece is turned while the part is being formed over a mandrel by applying rollers to the part surface under heavy pressures.

It is unlike spinning in that the metal shear is deformed from a heavy blank into the desired shape. Wall thickness of the finished part is a fraction of the original blank.

Most parts are made by this process in a single pass of the rollers. However, multiple passes or forming in stages, with intermediate anneals, may be needed for

more on next page



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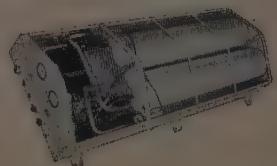
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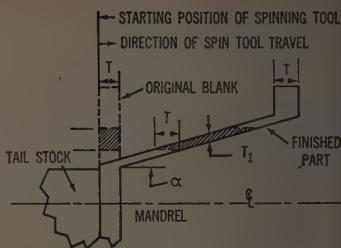


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MATERIAL reduction during spin forging depends on the configuration of the part being formed and is governed by the so-called "sine law", which states $T_1 = T \sin \alpha$ and $R = 100(1 - T_1/T)$, where T_1 is material thickness of the finished part; T , material thickness of the blank or preformed; α , half the included angle of the part, and R , material reduction. By substituting, we get $R = 100(1 - \sin \alpha)$.

the more complicated shapes or for materials with moderate to low ductility.

Marquardt Aircraft uses a 60x60-in. spin forge machine, built by Hufford Corp., El Segundo, Calif., to AIA specs, for the production of ramjet parts. It also intends to carry out development work on spin-forging. Application of the new method to "exotic" materials will be of special interest, Marquardt claims.

Material strength upped 100 per cent

The Hufford machine can form a one-inch thick piece of 321 stainless steel or other hard metal into an aircraft or missile part with little apparent effort. In forming the part, the machine increases the material's strength up to 100 per cent. It can apply a total work force of more than a million pounds in forming parts up to 60 in. in diameter and 10 ft high.

Marquardt specified 50 per cent reduction of metal thickness in one pass of the machine, ± 0.002 in. tolerance, 225,000 lb force up, down, and in and out on the cross slide, and 100,000 lb force up and 200,000 lb down on the tailstock. The tool it got is 25 ft wide, 24 ft high, including its base, and weighs more than 450,000 lb. A template tracer is used now, but provisions are made for the substitution of numerical tape control.

more on page 72

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→ SPACE/AERONAUTICS

ELECTRONICS

... In a busy manner.
[busy + -ness.] 1. Obs. work or personal concern; as, attend to business.
2. That which is a person's particular, esp. one's regular, work, occupation.
3. Affair; matter; as, it was a strange business.
4. The details in acting or staging a play usually of actors or director.
5. Industrial enterprise; as, he preferred business to law.
6. Mercantile pursuit or occupation; as, to increase business by advertising.
7. See work.
Business, commerce, in industry, as here used, often an inclusive term, specifically names of those engaged in the purchase or sale of commodities, especially by manufacturing scale that problems of labor and capitalized in the operation of public carriers, etc.

Displaying the effi-

Business

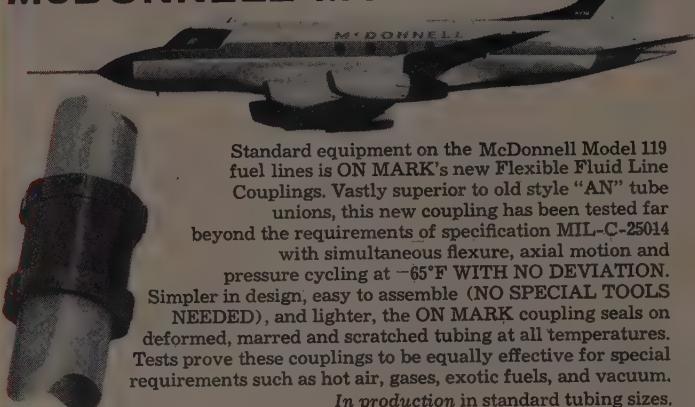
The 8th definition of business, according to Webster, reads as extracted, "... to increase business by advertising." This advertisement has the sole purpose of offering the capabilities of BJ Electronics, Borg-Warner Corporation, to military suppliers for the manufacture of precision electronics. From your print specifications, this establishment will fulfill orders quickly and economically, utilizing 10 years of know-how and over 90,000 sq. ft. of new, completely equipped facilities. Consider your need, then . . . consider this a direct solicitation of your sub-contract electronic business.

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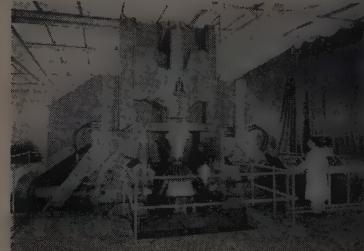
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HUFFORD spin forge can form parts—such as this truncated cone—up to 60 in. in diameter and 10 ft high.

The metal to be formed is placed on the spin forge's mandrel, which is shaped to the desired part, and held tightly in place by the vertical tailstock.

The mandrel then is turned at speeds infinitely variable from 10 mm to 400 rpm. Two massive working rollers, set across from each other at the sides of the mandrel, come in to force the metal over and around the form. The spindle is on a movable carriage so that it can be withdrawn horizontally for easy access to the mandrel and simple part handling.

Improvement in integrity of raw material

A distinct advantage of this technique is the potential improvement in the integrity of the raw material. Parts subject to extreme bursting or surface pressures in their applications may be thinner-walled and therefore lighter than before.

For the Marquardt acceptance tests, an inlet lip skin was made from one-inch-thick 321 stainless, with 50 per cent wall reduction in one pass. Acceptance tolerance on wall thickness was ± 0.004 in. Five consecutive parts were made with each slide working from its own template and another five with both slides working from a single template. All ten parts passed the acceptance tests.

In addition, titanium alloys and hot work die steels (such as the 5Cr series) have been formed. Still other hard-to-form materials should be formed by spin forging in the future, engineers told SPACE/AERONAUTICS.

The quality of the finished part is improved during the spin forge's roll forming by orientation and refinement of the metal grain. The

more on page 74

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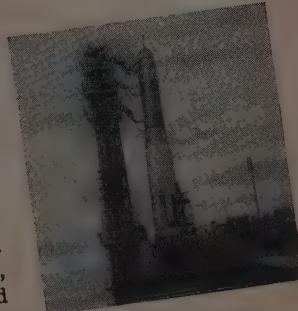
SPACE/AERONAUTICS

AVION RADAR BEACONS FOR ATLAS AND TITAN MISSILES

PARAMUS, NEW JERSEY—SPACE YEAR II—A contract for production of radar beacons for the U.S. Air Force Titan intercontinental ballistic missile nose cone has been awarded to the Avion Division of ACF Industries Incorporated, it was disclosed today by Richard F. Wehrlin, Avion President.

Radar beacons, Mr. Wehrlin said, are used to increase the range of ground radar while tracking the test firings of missiles, and the re-entry of nose cones, into the atmosphere.

In connection with their current space/avionic program, Avion has announced a new line of High Power C Band beacons. Send for literature.



PARAMUS, N. J.—A contract for production of radar beacons to be used in the nose cone of the Atlas ICBM has been awarded to Avion Division ACF Industries, Incorporated. "This contract represents the continuation of a series



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AVION

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grain, in effect, is caused to flow. Flow line and characteristics are changed to such an extent that better alignment results. Metallurgically, the grain condition of forging is obtained with close tolerances that eliminate the need for finish-machining.

Dan W. Burns, Hufford president, cites the forming of a torus (curved) bulkhead made from 4130 steel with a tapered wall thickness from 9/16 to 0.1 in. as an example. The metal was in fully

spheroidized annealed condition, and before roll-forming it had a tensile strength of 80,000 psi, with a hardness of 90-96 Rockwell B.

After forming, the material in the part had 160,000 psi in tensile strength, grain elongation of 4-6 per cent, and 35-37 Rockwell C hardness. Also, the surface finish of a roll-formed tubular part will be about six in. inside and 40-60 in. outside.

Furthermore, Burns adds, the tubular central section of the pres-

sure vessel or casing, common to most propulsion units, generally is made with the warp-and-weld method. With this method, a unit 100 in. long and 50 in. in diameter has a usual production cycle of four hours.

"Finishing" would take only 45 minutes

Roll forming of this piece on the spin forge would take about five minutes and handling time. The tube would be made by placing a "doughnut", or ring of metal, containing enough material to make the entire piece on the spin forge mandrel. By using the work force of the machine, the metal would be made to flow vertically.

A ring 25 in. in height and with 3/4-in. wall thickness (50-in. ID) would be used to make a finished piece 100 in. high with 3/16-in. wall thickness. The only "finishing" required, before the piece could be joined to other sections of the pressure vessel, would be machining of the open ends, an operation requiring about 45 minutes.

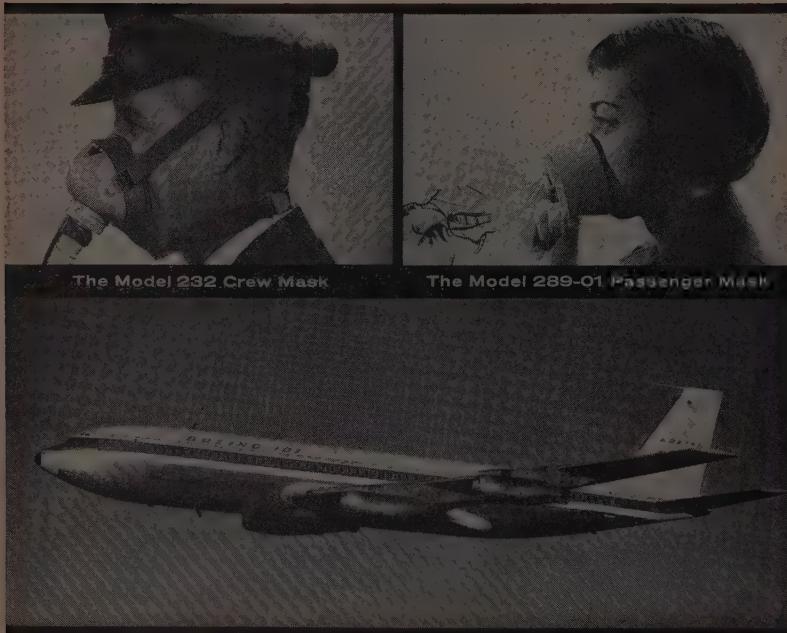
Fewer welds are needed with spin forging

A key factor from the standpoints of cost and quality of the finished part is the elimination of the longitudinal weldments and the decrease in the number of transverse welds generally associated with parts made by the warp-and-weld method. By eliminating major weldments in the tubular sections, the spin forge eliminates possible points of failure.

Another part was made from a 9/16-in. flat plate of 6061Al(T5). It was formed in three passes—the first loose, the second to 0.04 in. tolerance (and followed by solution treatment to the W-condition), and the third tight to the mandrel. The final part was 17 1/4 in. deep and had a six-inch maximum diameter and a wall thickness of 0.125 in. at the top and 0.190 in. at the other end. The minimum wall so far drawn with the spin forge is 0.06 in.

Two more spin forge units are being made. One will be delivered to General Electric for the roll-forming of jet engine turbine shafts and other parts; the other will be used by Hufford to form 72-in.-diameter parts of surface-of-revolution shapes. Write in No. 69 on the Reader Service Card for more information.—End

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Write for 44-page, 2-color Plug Guide, Bulletin CPG-3

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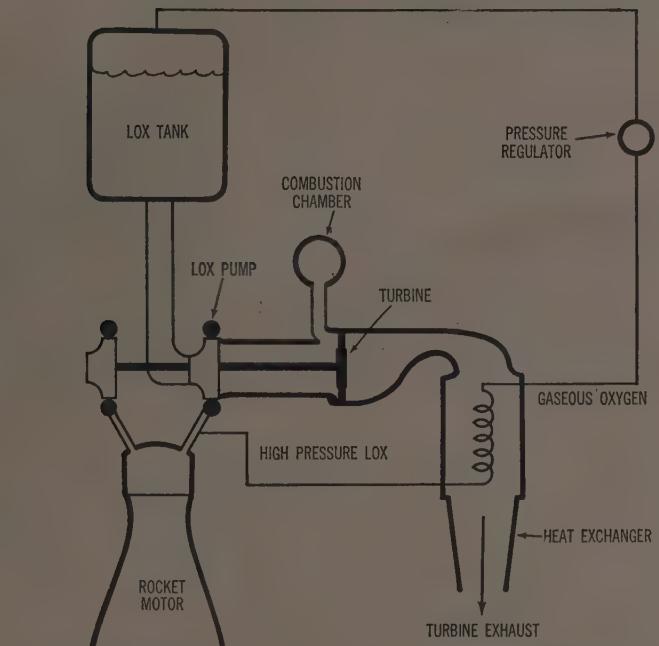
External wire fins for compact missile heat exchangers

With weight an even more critical factor in missile design, every subassembly must be rigorously examined and re-examined to obtain top efficiency. Here's one promising new approach to provide lighter and more efficient missile heat exchangers.

EXTERNAL surface area is a critical item in designing heat exchangers for missile fuel systems—it determines how fast heat is transferred into the exchanger tubes from the external medium (see *Schematic*). But how can it be made large enough without raising weight and size problems? A promising solution to this puzzle has been developed by Technical Products Div., Waste King Corp., 5550 Harbor St., Los Angeles, Calif.—attaching wire or punched-disk assemblies to the outside of the heat exchanger tubes.

This approach resulted from a company study that indicated that brazing conventional spun or upset fins or similar units to the tube did not provide enough area. Waste King's engineers then came up with the idea of coiling wire in an oblong shape, wrapping it around the outside of the tube like a spring, and brazing it on.

This method, Boyd T. Marshall,



HEAT EXCHANGER installation in typical liquid propellant rocket.

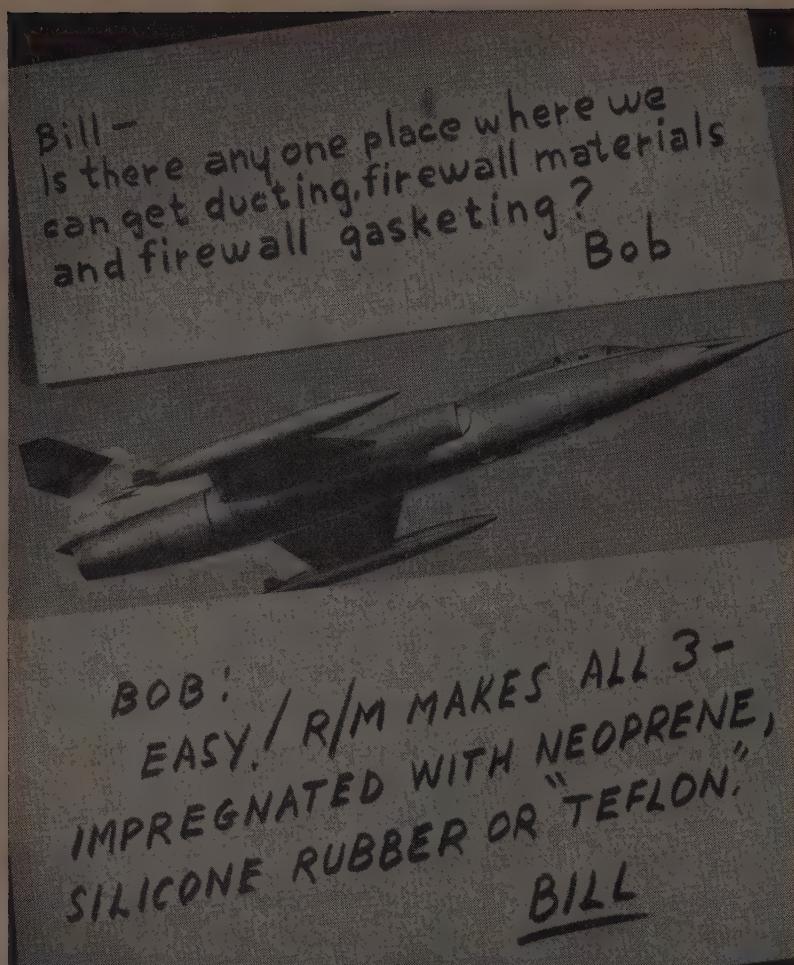
vice president and technical manager of the Technical Products Div., told *SPACE/AERONAUTICS*, provides very large external surface areas. It also automatically provides for external flows going either lengthwise or crosswise.

For most of the present work, pure copper wire—nickel-plated for corrosion resistance—is brazed to 321 stainless steel. External-to-internal surface ratios as high as 20 have been provided, though in most instances ratios of 16 proved enough. The coil wire, chief engineer A. J. R. Schneider told

SPACE/AERONAUTICS, is extremely useful wherever the external film coefficient is very low and the internal one is high.

An alternative method was also devised, using series of punched disks. Each disk has a little upset collar with a thin slit in it that separates each disk from its neighbors. This setup, engineers state, provides a continuous copper coating at the tube level that distributes heat along almost 100 per cent of the surface area, providing uniform heating of the basic steel wall. An

more on next page



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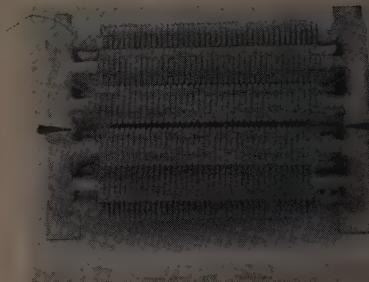
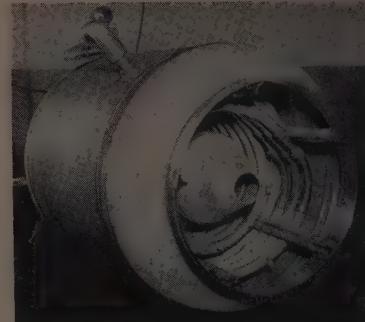
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HEAT EXCHANGER in production for missile powerplant system (top) weighs 37 lb and is 26 in long. Proposed replacement using wire fin assembly (bottom) weighs only 10 1/4 lb, with a length of about 16 in.

edgewise method of attaching the disks, they point out, would result in concentrations of heat. The maximum external-internal surface ratio obtained so far is 10.

Higher surface ratios than those achieved so far could be obtained with both types of fin designs. However, a limit is set, says Schneider, by the ratio between the film coefficient on the outside surface and the thermal conductivity of copper. You could conceivably get ratios of 30 or 40, but the question is then whether the heat could actually be transferred from the outer part of the wire or disk to the lower part. Weight is another factor—for extreme ratios, the problem arises as to how much good the extra material does as against its extra weight.

Wire fins are better for high ratios

Which of the two designs developed by Waste King should be used in a specific case depends on the properties of the two fluids in question, engineers note. When a

more on page 80

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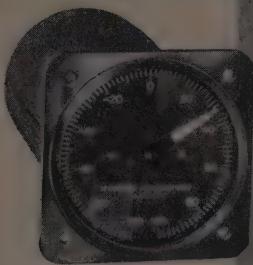
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OBLONG shape of external wire fin assembly developed by Waste King's Technical Products Div. is shown in this view of 10 $\frac{1}{4}$ -lb heat exchanger.

high area ratio is not needed, the disk type might be better because it's more economical.

Waste King's methods, it's claimed, permit the design of very compact heat exchangers. For example, one current production heat exchanger using plain tubing is 26 in. long and weighs 37 lb. A prototype redesign of this unit for wire fins is said to provide the same thermodynamic performance for a length of only about 16 in. and a weight of 10 $\frac{1}{4}$ lb.

In the overall exchanger design, environmental properties must be considered as carefully as thermodynamic ones. The engine gives out a tremendous amount of airborne noise. This noise contains just about every possible frequency so far as sound is concerned. As a result, lightweight structures must be carefully designed to prevent fatigue or cracking under vibration. The answer to this, Waste King has discovered, is primarily one of detail design: proper ways of making welded joints to prevent fatigue, proper ways of supporting the coil system, etc.

Close quality control is needed

This particularly involves problems of quality control, Schneider states. In building leak-free units, engineers presently find the most serious problems to be in the parent metal, since welding methods have been devised to eliminate welding

more on page 82

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A TO D SERVO CONVERSION SYSTEMS

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NORTH ATLANTIC industries, inc.

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"Forget the umbrella. Herman..."

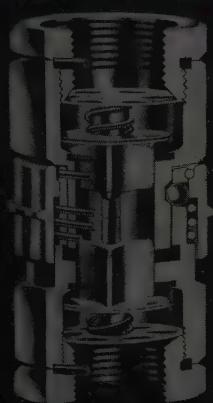
Snap-Tite *valved* couplings stop flow instantly™

Snap-Tite provides instant shut-off wherever fluid coupling is needed.

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Snap-Tite couplings are available in sizes from $\frac{1}{4}$ " to 6" ID, in steel, brass, aluminum, 303 ss and 316 ss. Sizes from 6" to 10" ID are available on special order. For more information, write for Snap-Tite catalog #58. Snap-Tite representatives are located in all principal cities.

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...with valve to carry
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Built to handle high pressure
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In the unknown reaches of outer space... where accuracy and dependability count... you can count on precision-made Chandler fasteners for maximum resistance to vibration, fatigue and high temperatures.

Made from high carbon, alloy, super-alloy and stainless steels, Chandler cold-rolled fasteners are checked at every phase of production to assure absolute uniformity and conformity to customer specifications. For the aircraft industry Chandler produces high quality "AN", "NAS" and special aircraft engine bolts to meet individual requirements.

If you are looking for fasteners at a realistic price to meet your very special requirements, write us today.

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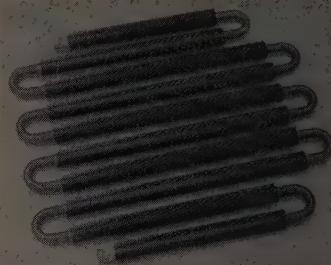


chandler
products corporation

1493 Chardon Road • Cleveland 17, Ohio

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HEAT EXCHANGER . . .



PUNCHED-DISK fin assembly shown here is alternate method devised by Waste King.

defects. The process used is basically shielded-arc (Heliarc) with argon gas—but with step-by-step care and attention to detail. A prime requirement here is having welders with excellent technique.

Precise testing methods are also needed. Waste King can detect leaks on the order of $\frac{1}{100}$ cu in./min. when the internal pressure is 3000 psi helium. Basically, a submerged test in a tank filled with water and detergent is used. However, a great deal of the answer lies in correct preparation for the tests.

Numerous tests are run on assemblies during fabrication. Experience so far has shown few defects in the tubing. The main problem has been flaws in fittings made out of bar stock or in plates. Whenever tests indicate a defect, the part is welded up immediately.

Waste King buys the wire for its heat exchangers but does its own coiling. Careful attention is also needed in brazing the wire or disks, since pure copper tends to alloy with many brazing alloys. Here again, say engineers, it's a question of the right kind of preparation, of fluxes and detail as well as close quality control.

Work is also proceeding on systems to take a full internal pressure of 3000 psi at 1000 deg F. Different wire or disk material must be used, for copper won't take such high temperatures.

To give some idea of the design parameters of the new Waste King heat exchangers, Schneider revealed one point on the efficiency curve: For a wire-fin type with copper wire at an external-internal surface ratio of 16 and an external film coefficient of 50 hr/sq ft/deg F, fin efficiency is 90 per cent. Write in No. 75 on Reader Service Card for more information.—IS



HIGH TEMPERATURE CAPACITORS BY BENDIX

Now Available
in Production Quantity

E-315



Scintilla Division of Bendix developed and has in production the E-315 family of environmental resistant capacitors to aid in satisfying the fast growing requirement for high temperature components in the high speed aircraft and missile fields.

The E-315 capacitor offers proven stability of operation over the temperature range of -55° to $+315^{\circ}$ Centigrade* with no voltage derating and low capacitance variation. Of rugged hermetically sealed construction and nonstrategic materials, this capacitor is built for high altitude and severe environmental operation.

This nonpolarized capacitor is available in a variety of sizes in a capacity range of from 0.05 to 4.0 microfarads at 600 VDC. It is also available in higher voltage ratings. Performance data and operating characteristics are given in Technical Bulletin SL-61 which is supplied upon request.

*Confirmed by qualification test of 1000 hours at 100% rated voltage over ambient temperature range of -55° to $+315^{\circ}$ C.

DESIGN FEATURES

Temperature Range . . . -55° to $+315^{\circ}$ C. Capacitance . . . 0.05 to 4.0 μ f at 600 VDC. Voltage Range . . . 600 V to 3000 V per section. No Voltage Derating, Low Capacitance and Power Factor Variation, Environmental Resistant, Hermetically Sealed, Rugged Construction, Nonstrategic Materials, Minimum Size and Weight, High Altitude Operation.

Scintilla Division
Sidney, New York



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OUTBOUND

TIME

30 SEC.

2000°

100,000 FT.

TEMPERATURE

ALUMINUM

LOAD

10,000 LBS.

Second by second, higher-order performance is required of today's missile design—even as temperatures and loads are on the increase geometrically.

These are familiar problems to Shafer Engineers who have pioneered in the research and development of bearings to meet these higher-order requirements on many of today's outbound missiles. For example, Shafer research on the coefficient of expansion of materials—and the many other physical properties at elevated temperatures—establishes Shafer as a leader in high-temperature bearing design.

The famous exclusive design features that have made Shafer first choice for the toughest bearing applications in the airframe industry—greater capacity for its envelope dimensions and weight...

integral self-alignment with full capacity...greater resistance to shock loadings and vibrations—may provide the answer to your missile control system bearing problems.

The time for you to draw on Shafer experience is now—before you lay in bearings on your latest missile design. And remember, too, Shafer advantages can provide important answers to bearing problems on ground support equipment as well as the "birds" themselves. Before you lay bearings in—call on Shafer experience.

Shafer Bearing Division, CHAIN Belt Company, Downers Grove, Illinois.

SHAFER® BEARINGS
CHAIN BELT COMPANY

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NEW room-temperature vulcanizing silicone rubber from GE is applied as sealant (left) around the hot-air ducting used for de-icing the leading edge of the DC-8 wing. Right: Rigid metal duct and flexible connectors used on

the DC-8 to carry hot air for cabin heating, de-icing, etc. The duct is covered by a blanket of glass-cloth-reinforced silicone rubber. RTV silicone rubber is used to seal the seams and the ties at the end of the blanket.

New silicone rubbers meet tough DC-8 specs

A host of new sealing problems has been raised by the first generation of new jet transports. Here is a report on a variety of new silicone rubber compounds that had to be developed for the DC-8 and on their application.

by **R. T. Daily and R. W. Scholler**

Silicone Products Dept., Chemical & Metallurgical Div., General Electric Co. & Semco Research, Inc., resp.

THE Douglas DC-8 jet airliner uses many silicone rubber parts of entirely new design and made from new materials developed to Douglas' specs.

* Silicone Products Dept., Chemical & Metallurgical Div., General Electric Co., Mechanicville Rd., Waterford, N.Y.

One problem the DC-8 designers faced was the lack of a suitable material for fillet and faying sealing. Organic elastomers, commonly used as sealing materials, could withstand neither the skin temperatures nor the temperatures around hot air ducting.

Silicone rubber room-temperature vulcanizing (RTV) materials available at the time had the needed heat resistance but not the physical properties or high bond strength required on the DC-8. Douglas therefore called on GE's Silicone Products Department to develop a material that would meet its requirements. The result was a new line of RTV silicone rubber compounds that more than met the specs.

The new products have almost twice the physical strength of previously available RTV silicone compounds. They can be bonded to aluminum or other metals with a strength exceeding their own cohe-

more on next page

A NEW
DEVELOPMENT OF
AERO SUPPLY MFG. CO. INC.

This drag chute release is but one example of our abilities and capabilities in the area of original electro-mechanical design. Aero Supply has supplied a wide variety of control devices since the very earliest days of commercial and military aviation.



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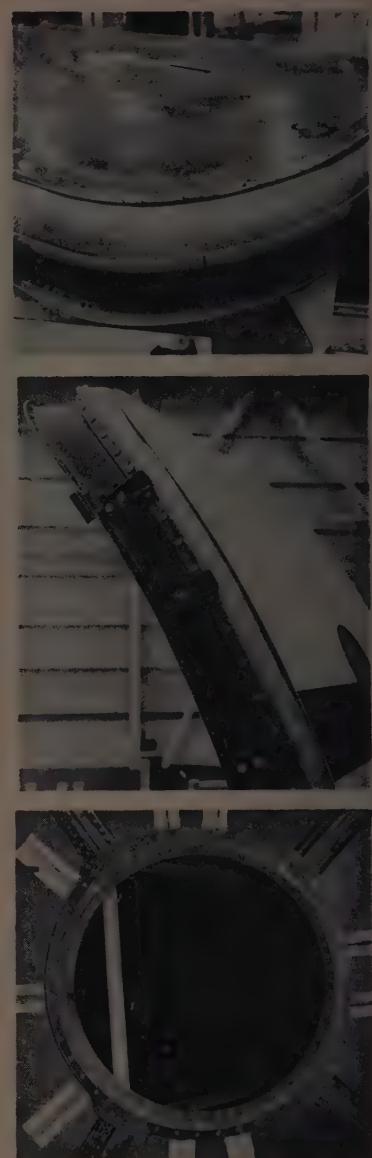
REQUEST BULLETIN #59-126 AND
OUR COMPLETE CAPABILITIES REPORT



AERO SUPPLY MFG. CO. INC.
CORY, PENNSYLVANIA

ELECTRO-MECHANICAL DEVICES • ENGINEERED FLUID CONTROL SYSTEMS • PRECISION MANUFACTURING

SILICONE RUBBERS . . .



DOOR and hatch seals made of high strength GE silicone rubber are used extensively on the DC-8.

sive strength. In addition, they have excellent heat resistance and more than adequate resistance to common aircraft fuels and fluids.

The new compounds are used extensively in the DC-8 for sealing and caulking on the interior of the wing leading edges, on hot air ducting, around radome noses, etc. For these RTV compound applications, Douglas developed new production methods, using equipment designed

more on page 88

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NOTABLE ACHIEVEMENTS AT JPL...

JPL PIONEERING CONTINUES WITH
THE LAUNCHING OF THE FIRST
SUCCESSFUL AMERICAN MOON PROBE



The JPL tracking station at Goldstone
in the Mojave Desert in California

Early on March 3, 1959, Pioneer IV space probe was launched from Cape Canaveral, Florida to become America's first deep-space vehicle capable of escaping the earth's gravitational pull. On its way past the moon and out into orbit around the sun, this new man-made planet sent back valuable information on the radiations present in space. Several Free World tracking stations clearly

received its transmitted signal and helped to establish its distance, velocity, and direction.

Under the sponsorship of the National Aeronautics and Space Administration, JPL designed and built not only the conical payload of Pioneer IV but also the three upper stages of the Juno II launching vehicle, containing new high-performance JPL solid propellant rockets.

Over a year ago the same JPL team, in cooperation with ABMA, gave America its first earth satellite, Explorer I, using a similarly reliable vehicle—the Jupiter C.

Now, more advanced space vehicle programs are under way at JPL—programs which include development of guidance and propulsion systems for accurate maneuvers many million miles from the earth.



CALIFORNIA INSTITUTE OF TECHNOLOGY
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with this Repair Shop
on Wheels

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Get any part of the set or make substitutions either in tools or the drawer combinations to fit your own needs.

IT'S IMMEDIATELY AVAILABLE

— wherever you are! With 58 branch offices throughout the U.S. and Canada, you can get this set or any other *Snap-on* tools on short notice.

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SNAP-ON TOOLS
CORPORATION
8080-E 28th Avenue • Kenosha, Wisconsin

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by Semco Research, Inglewood, Calif.

The compound is catalyzed by machine mixing. It is placed in plastic cartridges, which then are stored in refrigerated containers to retard the curing action of the catalyst. Workmen withdraw the cartridges as needed and insert them in specially designed pressure guns for application.

As soon as the RTV compound returns to room temperature, curing takes place at a rate determined by the type and amount of catalyst used. Plastic cartridges and nozzles for the pressure guns are discarded after use.

RTV silicone rubber is only one of many new silicone materials used on the DC-8. Door and hatch seals, which must retain their flexibility at —65 F, also had to be made from silicone rubber. But Douglas was not satisfied with the physical strength of the available products. To keep down maintenance costs, it wanted more rugged seals.

Fortunately, another breakthrough provided the needed material when GE introduced the new SE-555 high strength silicone rubber. This material is used throughout the DC-8 for seals and gaskets. For pressure seals, SE-555 is calendered on both sides of a Dacron* fabric, the seals are then made to shape. Designed by Douglas and made by Los Angeles Standard Rubber, this construction provides a flexible seal with a physical strength not available before.

Great quantities of hot air are needed for heating the cabin and de-icing on a plane as large as the DC-8. All flexible ducting and connectors are glass-fabric-reinforced silicone rubber, which prevents fatigue failure from vibration, a problem with flexible metal ducts.

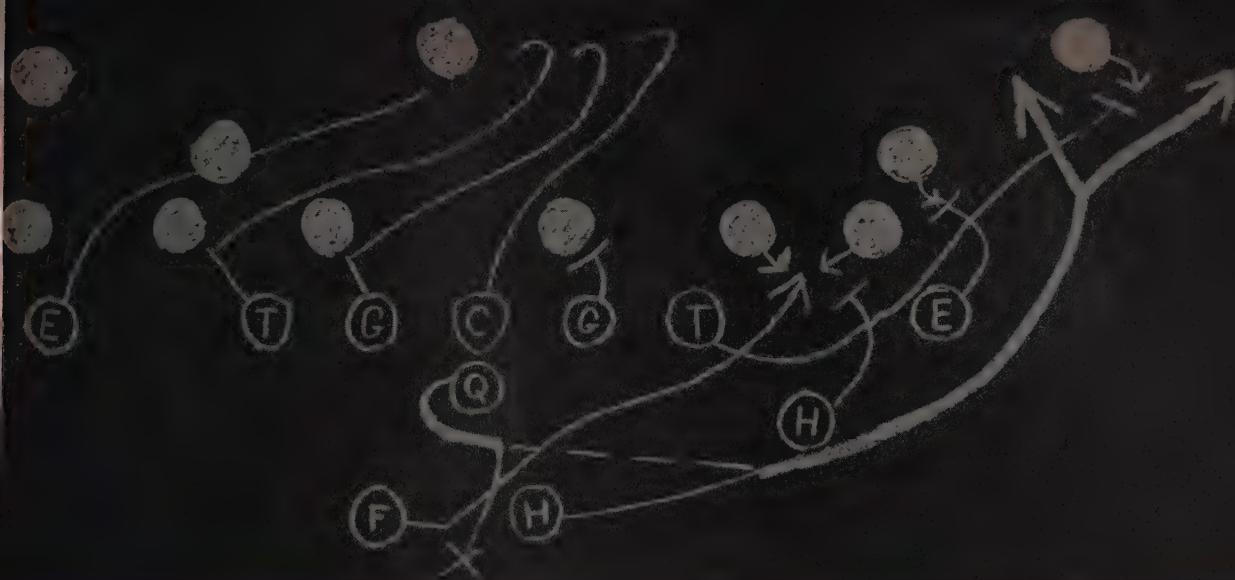
GE's SE-701 silicone rubber was chosen for this because of its heat and flame resistance. For added safety, Douglas also came up with a new concept in duct design.

The flexible connectors are of double-wall construction. Either wall has more than enough strength to withstand the required air pressure. The connectors have indicators to warn of inner-duct failure, so a faulty unit can be replaced immediately.

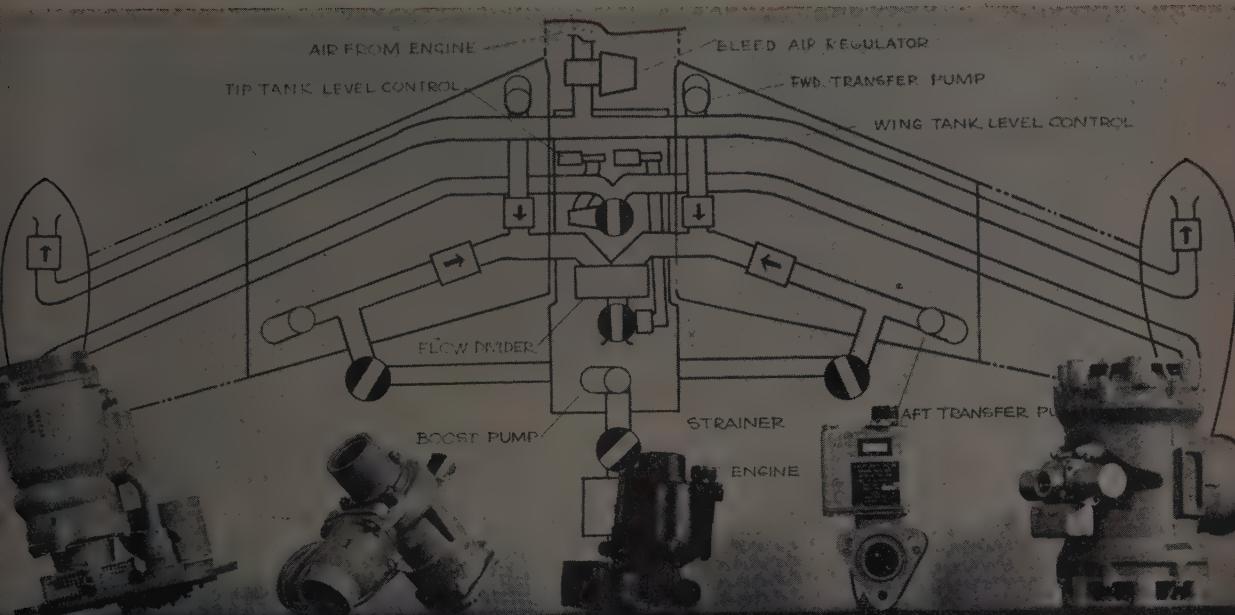
The double wall also reduces

* Registered trademark, E. I. du Pont de Nemours & Co.

more on page 90



Team planning...



For successful fuel control

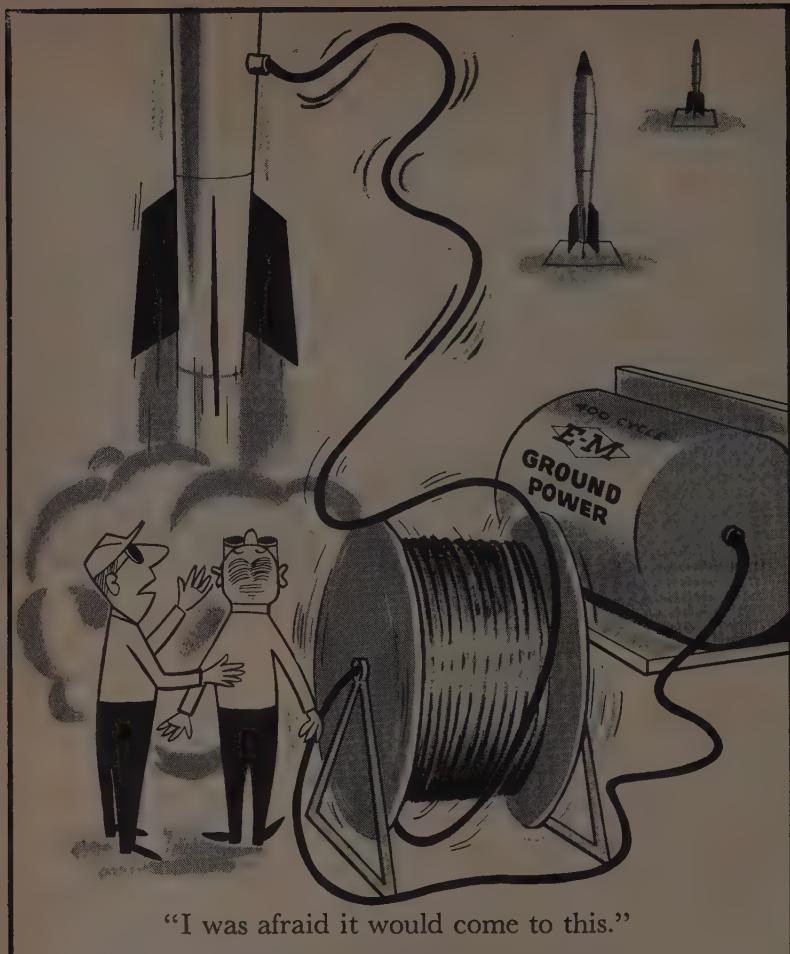
Booster pumps, transfer pumps, shutoff valves, selector valves, regulators... In the complex fuel-control system of a supersonic aircraft or missile, not only must each component be individually flawless, but all must function perfectly together.

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Producing Controls for Every
Basic Airborne System



"I was afraid it would come to this."

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Whatever your requirements in 400 cycle ground power equipment, E-M's large staff of specialists, with unmatched 400 cycle generator experience, can help. Missiles and jet aircraft that now have the advantages of E-M's imaginative engineering of 400 cycle ground power generators include Titan, Nike-Hercules, Snark, Matador, Hound Dog, B-47, B-58, and B-52.

Designing and building 400 cycle generators to meet the exacting requirements of missile and jet applications requires a big investment in experienced, technical manpower and plant facilities. Ask your nearby E-M Field Engineer to show you his copy of "Ground Power for Space". It's an informative picture story of E-M's investment in your 400 cycle ground power needs.

FREE 28-PAGE ILLUSTRATED BOOKLET offers many answers to your 400 cycle ground power questions. Write the factory for a free copy of "ABC of 400 Cycle Generators and Their Control". It's packed with useful information about performance characteristics and mechanical construction of 400 cycle ground power generators.



ELECTRIC MACHINERY MFG. COMPANY
Minneapolis 13, Minnesota

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heat loss. For this reason, a similar design was used on the rigid ducting. Covers of glass-cloth-reinforced silicone rubber are wrapped around the ducts and joined and secured with RTV silicone rubber.

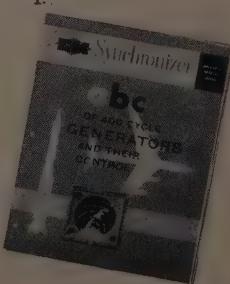
Aircraft designers may expect soon such advances as the recently announced nitrile silicone rubber, with outstanding resistance to common fuels and lubes; new aircraft wire construction taking advantage of the flexibility, heat resistance, and improved physical strength of new silicone rubbers; as well as a broader line of high strength rubber compounds. Write in No. 74 on Reader Service Card for more information.—End

books

Fundamentals of Advanced Missiles, by R. B. Dow. Dr. Dow, Aeronautical Research Administrator, Air Force Office of Scientific Research, here emphasizes basic principles that can be used to estimate the performance of guided and ballistic missiles and spacecraft. Subjects include properties of microwaves, application of infrared radiation, radar, dynamics, fluid mechanics, etc. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. \$11.75.

Analysis & Design of Aircraft Structures, Volume I, by E. F. Bruhn, assisted by A. F. Schmitt. This first volume of the 1958 revised edition of Bruhn covers analysis for stress and strain. Volume II, which is in preparation, will cover strength analysis and design. Tri-State Offset Co., Cincinnati 2, Ohio. \$8.75.

Nuclear Rocket Propulsion, by R. W. Bussard & R. D. DeLauer. Written by two Los Alamos scientists, this book is designed to bring together the technology of the reactor physicist and engineer with that of the space-missile designer. System analysis, materials and structures, and rocket performance are some of the subjects covered. McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N.Y. \$10.

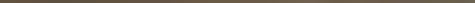




THE HI-LOK AUTOMATIC FEED DRIVER, FITTED TO AN INGERSOLL-RAND AIR MOTOR, ASSEMBLES UP TO 200 COLLARS ONTO HI-LOK PINS WITHOUT RE-LOADING. ASSEMBLY RATE: UP TO 45 PER MINUTE.



HI-LOK IS BEING ASSEMBLED UNDER WING RIB IN EXTREMELY TIGHT QUARTERS USING A HI-LOK 20° RATCHET WRENCH ATTACHMENT AND KELLER AIR MOTOR.



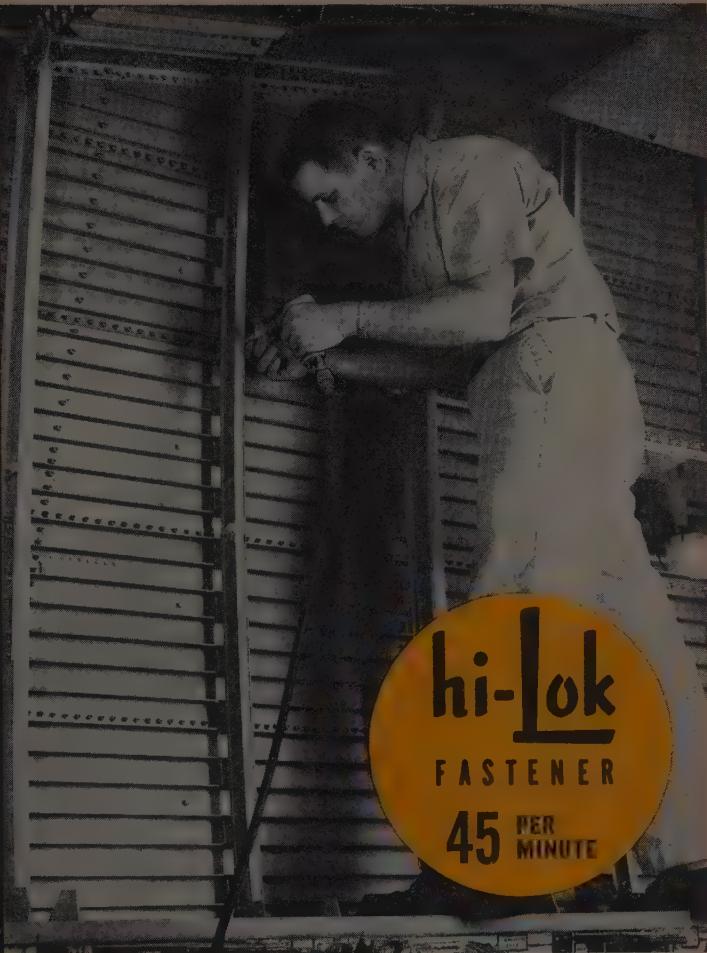
HI-LOK IS BEING INSTALLED WITH LIGHTWEIGHT TOOLING IN PLANK SPLICING OF ELECTRA "WET" WING.



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MINIMUM TOOL CLEARANCE CONDITIONS ON STIFFENERS IN WING FRONT SPAR ARE EASILY MET WITH HI-LOK ADAPTOR TOOLING COMBINED WITH INGERSOLL-RAND AIR MOTOR.



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Automatic assembly of high strength Hi-Loks up to 45 per minute, is one of many producibility factors which enables Lockheed to produce a finished Electra in only 88 days.

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MAGNESIUM



a comparison:

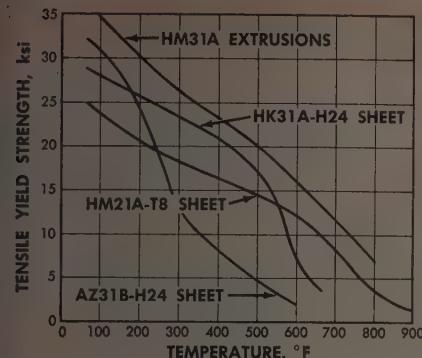
4 MAGNESIUM ALLOYS for elevated temperature service

A wide variety of elevated temperature alloys extends the use of lightweight magnesium into the critical 300°-800°F. temperature range.

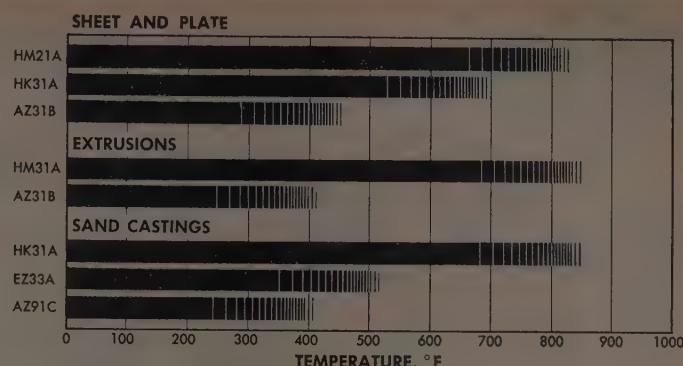
Name your weapon—Jupiter C, Polaris, Talos, Discoverer, Falcon or Bomarc. All make extensive use of elevated temperature magnesium alloys. Improved resistance to creep, increased stiffness and strength and exceptional shop characteristics are the long suit of these materials. At elevated temperatures they maintain a high ratio of fatigue strength to static strength. (About the same ratio as standard magnesium alloys at room temperature.)

SHEET AND PLATE

Alloys HK31A and HM21A have been widely used for many different parts in missiles, rockets and aircraft. Some of the most common applications include body skins, engine air inlets and ducts, nose cowlings and cones, external and internal skins on control surfaces. HK31A extends the usefulness of light-



New alloys have extended magnesium's useful service temperature range.



A comparison of short-time tensile yield strength exhibited by a standard magnesium alloy and the commonly used elevated temperature alloys.

weight magnesium to a temperature of 500°F. and above. HM21A withstands temperatures up to 700°F. and higher for short time periods. And it exhibits better creep resistance above 350°F. and better static properties above 550°F., than does HK31A.

FORGINGS

At operating temperatures up to 800°F., HM21A offers excellent mechanical properties, optimum creep resistance. HK31A has better room and elevated temperature properties up to 400°F. Both have good forgeability.

CASTINGS

Engine air inlets and ducts and housings for electronic guidance systems are examples of the many applications of cast magnesium alloys HK31A and EZ33A. EZ33A has good general properties in the 350°-500°F. range. HK31A is recommended up to 700°F. and above. Components of military systems weighing as much as 105 lbs. have been cast in one piece with HK31A. A new elevated temperature alloy for die casting is now in development and will soon be available.

EXTRUSIONS

Alloy HM31A has put the many benefits of elevated temperature magnesium into extrusion form. This alloy is used as ribs and horizontals in missile bodies, instrumentation booms and external tunnel fairings for wiring and plumbing, etc. HM31A maintains high elastic modulus, excellent creep resistance and strength at elevated temperatures. Elevated temperature exposure at 600°F. for 1,000 hours causes no change in room temperature properties and only a slight drop in creep strength.

ELEVATED TEMPERATURE MAGNESIUM EXCELS IN PRODUCTION

The elevated temperature alloys possess the best welding characteristics of all magnesium alloys. Arc welded joints can be easily made and welding compatibility of magnesium alloys is excellent. For example, HK31A sheet can be welded to HM31A extrusions.

Weld efficiencies at room temperature range from 70% to 80%. At temperatures above 400°F., HK31A has a weld efficiency of 100%. The same goes for HM21A above 500°F. In general, preheating and stress relieving are unnecessary with these alloys. They can be readily spot welded and are not subject to cracking.

Machining operations can be carried out at extremely high speeds, with heavier depths of cut and higher rates of feed than are possible with other metals. All chemical treatments used to finish standard magnesium alloys are

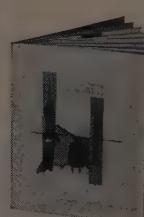
applicable to the elevated temperature alloys, with the exception of Dow 7, which does not coat satisfactorily on magnesium-thorium alloys. For extended service above 400°F., the anodic treatments are preferred.



Elevated temperature alloys possess the same excellent shop characteristics—such as machining, forming and welding—as the standard magnesium alloys.

MAGNESIUM ALLOYS FOR ELEVATED TEMPERATURE APPLICATIONS

SHEET	HK31A HM21A
PLATE	HK31A HM21A
FORGINGS	HK31A HM21A
CASTINGS	HK31A EZ33A
EXTRUSIONS	HM31A



WRITE TODAY for this new 27-page illustrated brochure on magnesium alloys in aircraft and missiles.

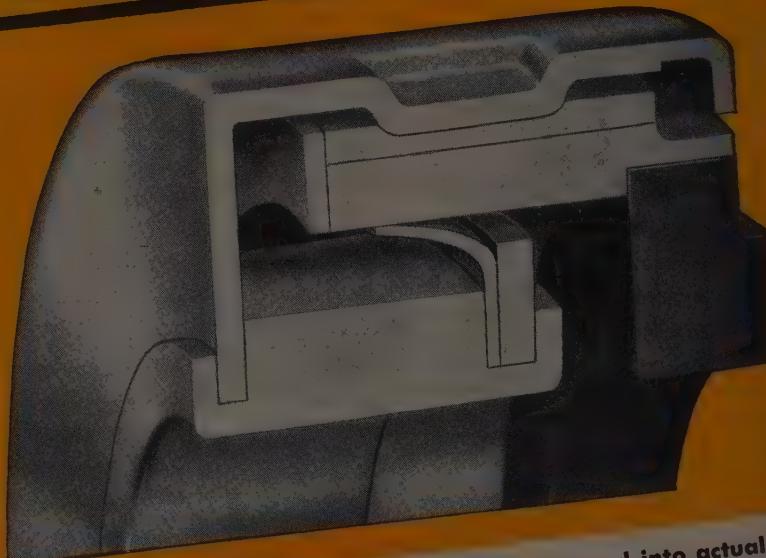
THE DOW CHEMICAL COMPANY,
Midland, Michigan,
Magnesium Sales Dept.,
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THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

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NEW

Only Gits Met-L-Seal*
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Now beyond the Research-Development Laboratory and into actual production — nothing like it on the market! Consider these exclusive design advantages, producing a built-in "missile reliability":

- 1 Hydraulic balance producing optimum sealing under both static and dynamic conditions — not always available in other all-metal seal designs.
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- 4 No "shelf life" problems. No "cure-date" limitations as are necessary with synthetic-elastomer seals.

Send for new "Advance Catalog" or submit your seal problem to the experienced engineers of the Gits Aircraft and Missile Seal Division.

GITS

BROS. MFG. CO.

Aircraft and Missile Seal Division

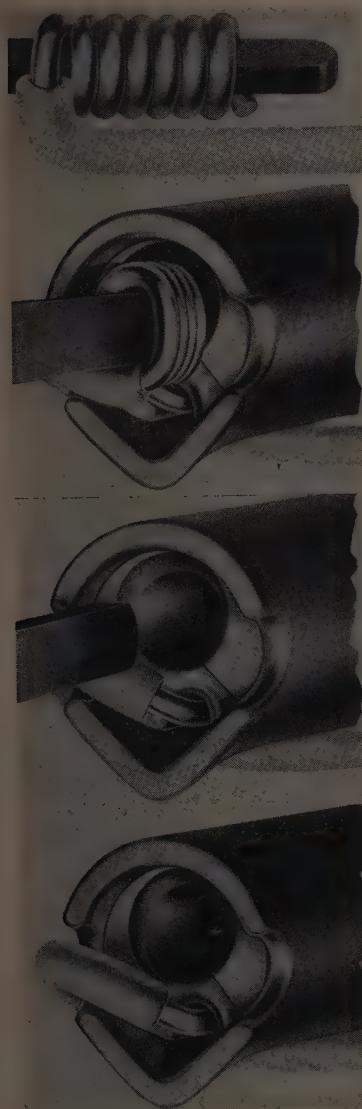
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all stainless steel
construction with
carbon graphite or
exotic alloy
face materials





WIRE-WRAP cycle: (1) Operator inserts wire into a wrapping bit and skins it according to the desired number of turns. (2) He places the wrapping bit over the terminal and triggers a pneumatic or electric power source to rotate the bit. (3) The rotating bit spirals the wire tightly around the terminal. Many connections have six turns of wire, though four are more than adequate. (4) The operator removes the bit, which is automatically positioned for the next cycle. About 1½ in. of bare 24-gage wire goes into a six-turn connection.

Write in No. 26 Reader Service Card
May 1959

Automated Wire-Wrap cuts production costs in half

Wiring by wrapping is said to be ideal for airborne gear, since mechanical wiring connections have better vibration resistance than soldered ones. The technique also lends itself readily to automated production and high density circuit design.

ONE of the oldest methods of completing a link in an electric circuit has come into its own once again—the solderless Wire-Wrap* connection. Its principle is not complex: Wire is inserted into a wrapping bit, the bit barrel is placed over the terminal, and power applied to rotate the bit and wind the wire around the terminal. In a tenth of a second you have a tightly wrapped electric connection.

The wrapping force is so great that the high shearing force of the wire scrapes off surface film from both the wire and terminal to produce a clean metal-to-metal contact that is free of oxidation. As the connection ages, it becomes stronger through solid-state diffusion between the wire and terminal contact points.

Initial pressures in the center of the contact areas go as high as 100,000 psi. Cold metal flow relieves the pressure to a level over 29,000 psi, at which point the metal stabilizes and the pressure remains constant.

With 24-gage wire, four turns

produce a total contact area of 400 square mils. The cross-section of the wire itself is only 314 square mils.

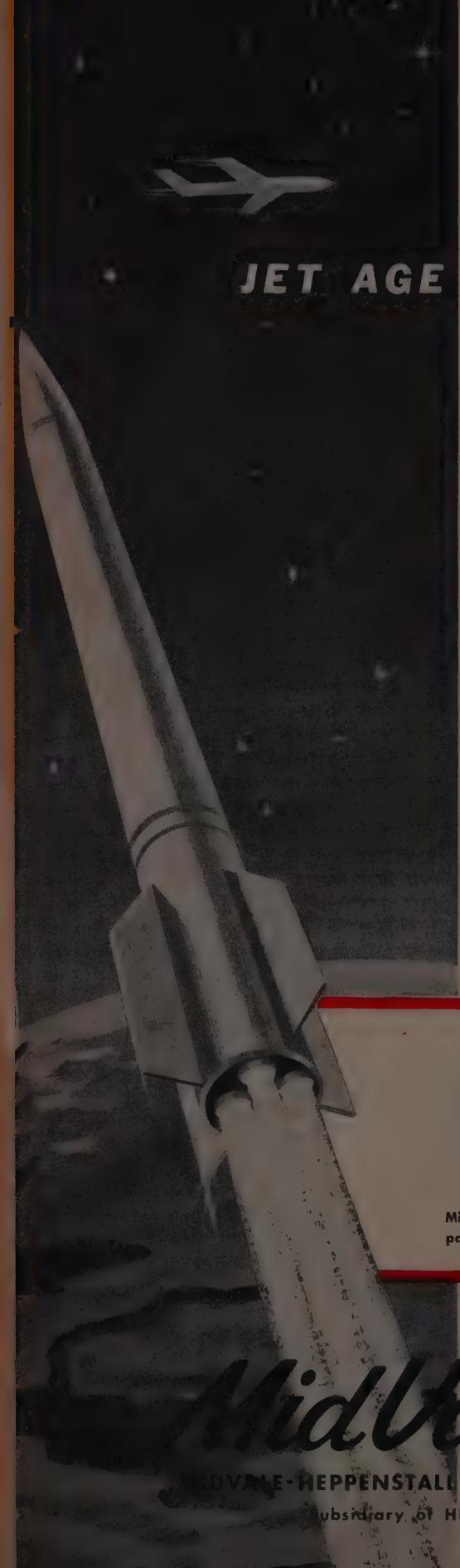
As a result of greater contact area and of the pressure contact, the stripping force of the connection with 24-gage wire is 25 per cent higher than the force required to break the wire. Normally, a stripping force of 3000 gm (6.6 lb) is considered satisfactory for 24-gage wire connections. Wire-Wrapped connections can take at least 5700 gm (12.5 lb) before yielding.

When Wire-Wrap was first introduced for aircraft and missile use, there was some question whether air or some other gas might come between the wire and the terminal. Reportedly, sulphuric-acid etch tests show clearly that the connections are gas-tight.

Some companies also felt the added weight of the terminals was more than that of the solder that had been eliminated. It is true that the weight of an subassembly chassis or wiring card might be higher with Wire-Wrap connec-

more on page 97

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ions on a volume basis. But the circuit density is also much higher. Hughes Aircraft's Missile System Division, for example, has gone to Wire-Wrap as the only way to get the density its engineers want. At the same time, Wire-Wrap made it possible to automate Hughes' electronic assembly operation.

For permanent solderless connections, the terminal generally must have one or more edges cross-wise to the axis of the wire. It must also be small enough to fit into the wrapping bit, but large enough to withstand the stresses placed on it.

A small width-thickness ratio makes it easier to maintain tension in a wrapped connection. In any case, the thickness should not be less than half the wire diameter and the width less than two wire diameters. Copper, tinned and untinned brass, phosphor bronze, or nickel-silver alloys can be used.

Wire-Wrap tools for making these connections are produced by Gardner Denver Co., Keller Tool Div., Grand Haven, Mich. There is a series of three tools to handle wire sizes of 18-26 gage — air-powered and electric pistol-grip tools and an air-powered straight-handle model. Wire sizes of 14 and 16 gage may be wrapped with two air-powered tools — a straight-handle model and a pistol-grip one.

Recently, an automatic tool was developed to wire computer sub-assemblies with 24 AWG solid wire on the "Lost Chord" airborne communications system being developed by Hughes. According to Gardner-Denver, the 4x4x5-ft machine reduces production costs by 50 per cent, compared with conventional wiring, by (1) simplifying the assembly operation, (2) eliminating errors, and (3) cutting down on inspection time.

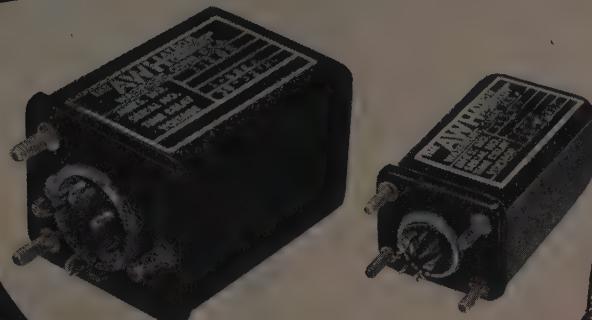
The automated tool can wire terminals in a 10x10-in. section of a 20x20-in. panel. It can be controlled manually by keyboard or automatically by punched tape.

For manual programming, a technician can work from a coded wiring list that specifies the operating sequence of two wrapping heads. Two connections can be put on each of the rectangular terminals. Even under high temperature conditions, the connection will maintain metal-to-metal contact. Write in No. 57 on Reader Service Card for more information.—VDB

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FEATURES

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FEATURES

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- inspection ports permit examination of conductors in barrel
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Never before has such a unit been available—a reliable, pre-insulated "manufacturing break" for aircraft and missile harnesses. Designed as a quick connect/disconnect for all high-reliability circuits, the all new A-MP HELICON Connector is completely environmental-proofed and fully pre-insulated. Equally important, it requires a special A-MP tool to connect and disconnect, thereby preventing tampering and unintentional breaks in circuits.

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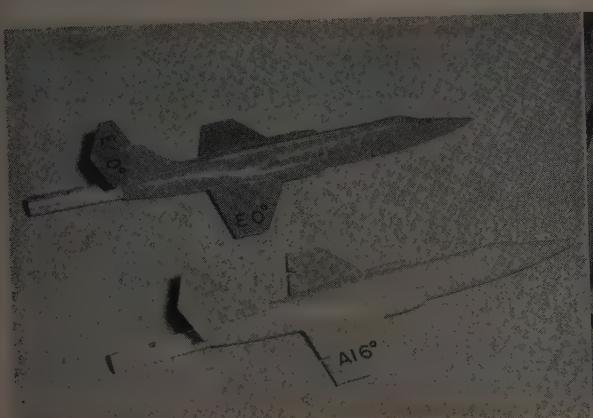
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TYPICAL F-104 test models (left) used in AFIT evaluation of commercial plastic kits. All depressions and cracks in the models were filled with plastic scraps, and all surfaces



were then sanded smooth. Right: Plastic F-104 model installed in AFIT's wind tunnel at USAF's Air University at Wright-Patterson AFB.

Cheap wind tunnel models from plastic kits

The cost and time of making accurate wind tunnel models raises quite a problem when it's a matter of merely running "ball park" tests on new configurations. Apparently the problem can be overcome very simply, though: Recent reports from USAF's Air University indicate ordinary commercial plastic model kits are fine for preliminary wind tunnel work.

THE cost of making a detailed wind tunnel model and the time the job would take have often been roadblocks in the evaluation/or study of new designs. A case in point occurred when officers at USAF Air University's Institute of Technology (AFIT), Wright-Patterson AFB, Ohio, wanted to observe performance of new types of craft, such as the Lockheed F-104. The minimum estimated cost of building a model with a metal wing in the WADC model shop was \$4000. And because of priority problems, the officers often would

have had to wait 9-15 months. The model size for the AFIT tunnel, which has a test section 14 in. in diameter and 32.5 in. long, was limited by tunnel wall effects to a maximum wing span of 10 in., an overall length of 18 in., and a frontal area of nine square inches. It was decided to look at the possibility of using regular plastic model kits for the studies. Several kits, made by Revell Co., 4223 Glencoe Ave., Venice, Calif., were bought and showed great promise.

As a result, Captains A. L. Brantley and D. W. Hall decided to make an independent study of the use of such models in tunnel

more on next page



Automatic antenna selector

Autonetics' new two-pound *Automatic Antenna Selector* eliminates antenna shading in military and commercial aircraft. Used with dual-antenna systems, it assures a strong, continuous signal. Does away with manual switching and losses due to coaxial tees in the antenna feedlines. Simple to install . . . has a 10,000-hour operating life with minimum maintenance . . . completely reliable during high-speed maneuvers and in environmental extremes. Meets stringent military requirements. Please write for literature.

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TUNNEL MODELS . . .



MODELS used for series of component tests. Of several types of commercial kits that were evaluated, Revell's proved best for test needs, Brantley and Hall of AFIT report.

Aerodynamic Characteristics of Model Components

Characteristic	Wing	Fuselage	Wing & Fuselage	Wing & Rudder	Wing, Rudder & Fuselage	Tail	Wing & Tail	Wing, Tail & Fuselage	Wing & Tips
$dC_L/d\alpha$	0.0616	0.00107	0.055	0.0583	0.0525	0.0143	0.0738	0.0632	0.0705
α_{L0} (deg)	+0.6		-0.45	+1.4	0	+2.4	+0.6	-0.9	+0.7
$C_{L_{max}}$	0.72*	0.03	0.68	0.705*	0.695*	0.17	0.865*	0.82	0.86*
$C_{D_{p0}}$	0.011	0.010	0.020	0.0125	0.020	0.017	0.014	0.030	0.026
$\Delta C_{D_{p0}}$			+0.09	+0.0015	+0.009	+0.006	+0.003	+0.019	+0.015
dC_M/dC_L	-0.286		-0.3425	-0.4665	-0.155	-2.0	-0.50	-0.84	-0.0972
$\Delta dC_M/dC_L$			-0.0565	-0.1805	+0.131	-7.714	-0.214	-0.554	+0.1888
e	0.465		0.420	0.457	0.428		0.498	0.5275	0.61

* indicates $C_{L_{max}}$ has a higher value at $\alpha > 15^\circ$

tests.* The F-104 looked best for this purpose, for its single-engine configuration permitted sting-mounting on the AFIT strain gage balance.

Because the model is so small, no simple way could be found to deflect the control surfaces so they would be rigid and yet accurately adjustable. Since the kits cost so little, it was decided to use a series of models, each with the controls cut out and cemented back at the right angle.

The tunnel models, except for the wing, were made from the materials in the standard Revell kit. Stings were glued into the fuselage with ordinary plastic cement. After this had dried, the rear half of the fuselage was filled with polyester resin to eliminate fuselage bending during tests. All depressions and cracks in the model surfaces were filled in with plastic scraps dis-

solved in carbon tetrachloride. When this dried, the whole outer surface of the model was sanded smooth.

The original control surfaces cut from the models couldn't be used, since cutting took out too much material. Instead, surfaces were cut from other models in outsize shape and then filed to fit the test models.

Surfaces were set with gage blocks

A series of small gage blocks were made to insure correct angular deflection of the surfaces by holding them in position until the glue dried. Control deflection was accurate within one degree, Brantley and Hall report. In addition to testing complete models, they separately tested components of the models, to study the interference of the components with each other.

Five series of tests were run on the characteristics of longitudinal motion in flight and two on lateral

more on page 102

* "Wind Tunnel Investigation of a Plastic Model F-104A" (thesis).

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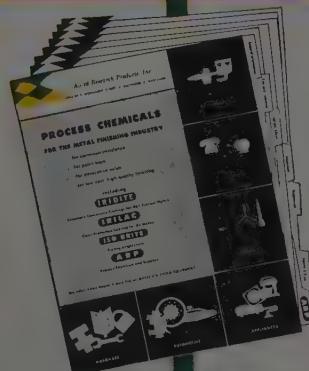
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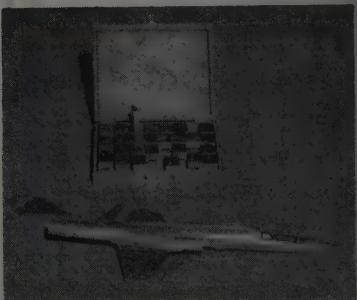


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TUNNEL MODELS . . .



STING mounting of model was done with ordinary plastic cement. When cement had dried, rear half of fuselage was filled with polyester resin.



SMALL gage blocks were used for accurate alignment of control surfaces during gluing.

motion. The longitudinal tests included studies of (1) combinations of subassemblies up to the complete plane and of the effects of (2) elevator deflections, (3) wing flaps, (4) landing configurations, and (5) tip tanks. Lift, drag, and pitching moment were measured.

One lateral series involved measurements of side force, drag, yaw, and rolling moment on the wing alone, on wing and tail, and on the complete model. The other covered rolling moments alone on models placed in the tunnel with wings horizontal and different elevator deflections.

Test values close to the theoretical ones

The Table shows a few of the results of the AFIT study. Brantley and Hall computed the theoretical slope of the lift curve to be 0.0572, as against an experimental value of 0.0611. For angle of attack, the F-104's symmetrical airfoil should have had an α_{L0} of zero degrees.

more on page 104

MARTIN
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Every day SCOTCH Brand High Resolution Tapes are getting the nod for more instrumentation jobs. The reason? Performance. In taping high frequency data, the sharper resolution lets you pack more pulses to the inch—a greater density of information to each foot of tape.

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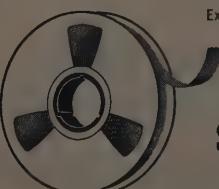
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for Hi-Strength at Hi-Temperature the Cherry "600" Rivet*



To meet the design requirements imposed by extremely high-speed aircraft and missiles, the Cherry Rivet research and development department has introduced the "600" A286

stainless steel blind rivet.

Data on the strength capabilities of the "600" rivet is available from Townsend Company, Cherry Rivet Division, P.O. Box 2157-P, Santa Ana, California.

REAR VIEW of plastic wind tunnel model, showing sting installed.

as against the test result of 4 deg. But this value was considered satisfactory, since accuracy in setting the angle of attack was \pm 1 deg. The e of 0.465 also seemed quite reasonable, Brantley and Hall

The values of $C_{Dp\alpha}$ and $C_{Lm\alpha}$ obtained in this series seemed higher than those of the previous series, which was attributed by Brantley and Hall to the low R_N of 224, and the assumption of negligible model interference due to the sting. The values involving C_M are considerably in error because of a sign feature of the strain gage balance system.

Because of interference effects between components, the characteristics of the components were found not to be additive. On the basis of its tests, AFIT personnel concluded that good results could be obtained with plastic models in all six degrees of freedom with suitable modifications of the measuring equipment.

Many Configurations can be tried

The outstanding value of plastic models, Brantley and Hall state, is that a large variety of configurations can be tested—models are so inexpensive that it is worth while to make a separate model to almost any desired form. Any model can also be easily and cheaply rebuilt in case of damage.

As a result of their studies, AFIT officers are considering additional tests to be run with similar models. One is a series on the F-105 to study aerodynamic braking during landing, to see if the landing roll can be shortened, and another would be concerned with blown flap problems. Write in No. 70 on Reader Service Card for more information.—IS

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Higher-Temperature Capacitors:

New Dielectric Materials Help Break the Heat Barrier

By Marc F. Warmuth, Staff Engineer, Airborne Accessories Corporation

Special Mylar*, Teflon† and mica constructions permit continuous operation up to 600°F

Three new types of special high-temperature motor-starting capacitors, utilizing Mylar, Teflon and mica dielectric respectively, have been developed recently by Airborne. The Mylar and Teflon types are wound of very thin metallized film for greatest possible miniaturization. The mica type is wound of a sandwich of aluminum foil and thin, pure mica ribbon, metallized mica not being procurable. All are encapsulated with thermoplastic polyamide or thermosetting epoxy resins (depending on temperature range) in sealed, cold-drawn steel cans with fused glass terminals. This construction provides low inductance units of exceptional mechanical sturdiness and environmental resistance.

As an alternate construction for less demanding applications, encapsulation in epoxy sleeves, with leads brought out through potted ends, is also available.

Mica for highest temperatures

The great advantage of mica as a dielectric is its ability to maintain its physical and electrical characteristics at temperatures up to 1000°F. All dielectric materials undergo severe reductions in

insulation resistance at high temperatures, but with mica the critical value is reached around 600°F. Full voltage ratings up to this point are thus permitted. And with the right epoxy resin impregnant, mica capacitors are well-able to withstand overtemperatures without damage... if not simultaneously subjected to full rated voltages.

Mica capacitors are three to four times larger than Mylar or Teflon units of comparable capacitance and voltage rating. This is because a greater thickness of dielectric must be used in addition to a separate layer of aluminum foil.

Mylar and Teflon for intermediate high temperatures and small size

Mylar can be worked continuously up to 300°F and Teflon up to 400°F. For applications below these limits, but above the normal 185°F limit of more conventional insulating materials, metallized Mylar and Teflon offer high dielectric strength. They make possible wound capacitors of very small size with good voltage ratings and excellent capacitance-to-volume ratios.

A further advantage of metallized Mylar and Teflon capacitors is their self-healing characteristic. The short occurring when the dielectric is ruptured

instantly burns the thin metallic coating back from the edges of the rupture, making further flashover impossible. Yet the amount of metallic coating burned away is so minute that hundreds of such self-healings have little effect on capacitance. Resistance to overvoltages can thus be considered excellent. Resistance to overtemperatures, on the other hand, is not an outstanding characteristic of Mylar or Teflon—a design factor to keep in mind.

Summary

MYLAR: For intermediate high temperatures, high voltage and smallest size. Continuous operation at 300°F with ratings up to 1000 WVDC. Capacitance variation with temperature good, but not as good as that of Teflon or mica types.

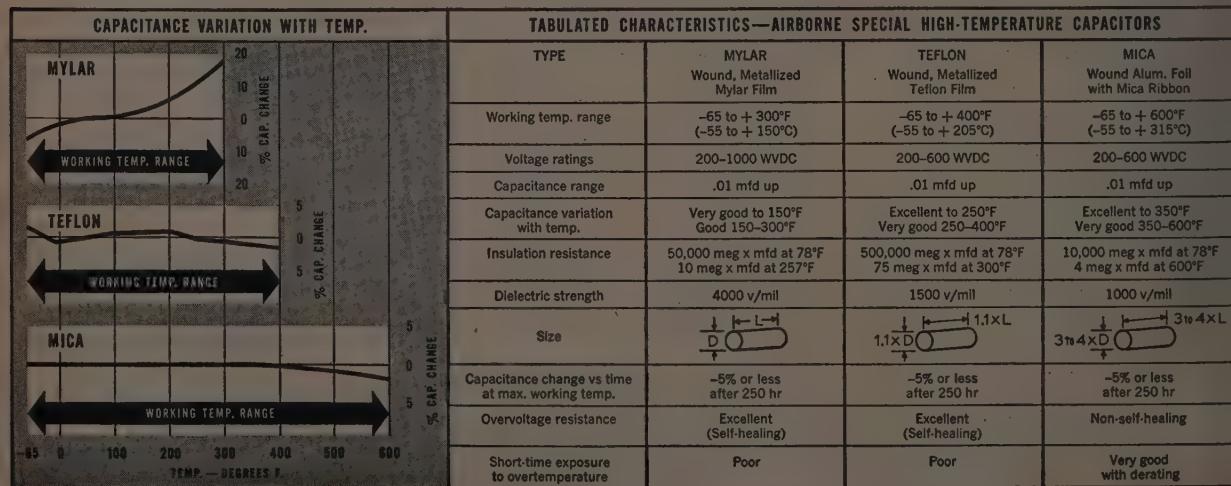
TEFLON: For intermediate high temperatures and small size. 600 WVDC up to 400°F without derating.

MICA: For highest temperatures. Continuous operation, 600 WVDC without derating up to 600°F. Higher temperatures possible with derating. Larger in size than equivalent Mylar or Teflon capacitors.

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†DuPont's tm for its tetrafluoroethylene resin



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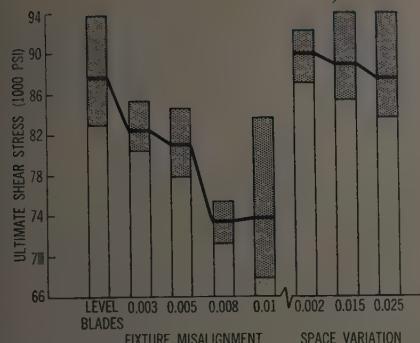
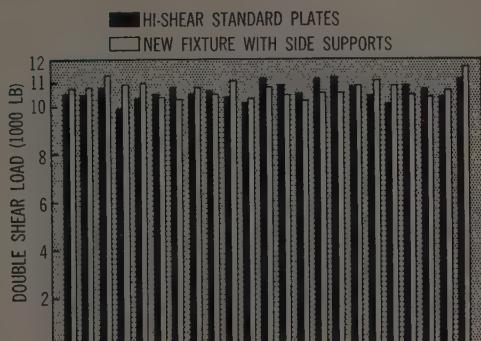
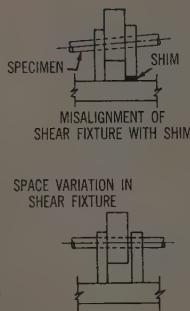
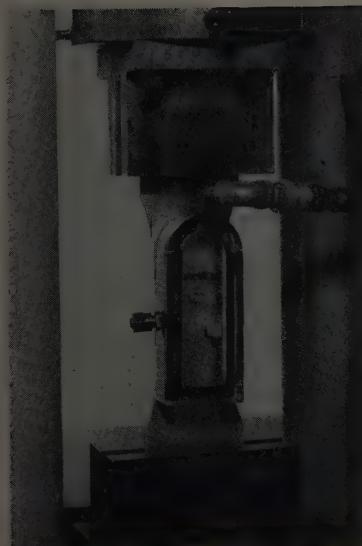


FIGURE 1: Effect of fixture variables (left) on shearing of titanium fasteners in Hi-Shear tests. Black lines show average of 10 tests. Right: Tests of 23 specimens



with old and new types of shear fixtures. Averages were 10,589 lb for the standard plates and 10,654 for the new fixtures.

New tests and materials for high temperature fasteners



PICKING fasteners for over 900 deg F calls for more attention to detail design both of the fastener and of its installation and to fastener testing methods. As strength levels are raised, W. A. Dickie, chief engineer of Hi-Shear Rivet Tool Co., 2600 W. 247th St., Torrance, Calif., told SPACE/AERONAUTICS, manufacturing deficiencies become

a more serious problem for fastener installations.

High performance fasteners require harder materials with less elongation, so that they're limited in redistributing loads. Alignment of the hole, type of countersink, and similar factors then become more critical. More attention will

more on page 111

INGENUITY in devising test setups is a key factor in high strength fastener evaluation. An example is this sealing test for a fastener under fatigue load. The fastener is covered with a glycerin-filled chamber that is vacuum-sealed to one side of the shear coupon. A capsule of red dye is mounted on the other side. If there is any leakage, the dye will show up in the glycerin.

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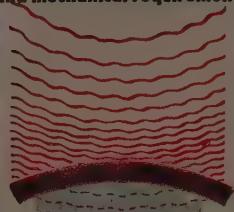
BUSINESS ACHIEVEMENTS:

PAST - FD-1 Phantom - First all-jet airplane to take off and land on aircraft carrier.
F2H Banshee - Famous Korean War fighter jet.
Little Henry and XVI Convertiplane - First ramjet helicopter. XVI Convertiplane made first successful conversion from helicopter to airplane flight.
PRESENT - Talos - the airframe and power plant of this missile designed and developed at McDonnell.
F-101 Voodoo - Holder of three transcontinental speed records.
the F-101B Interceptor now in quantity production.
F3H Demon - Missile carrying all weather Navy fighter now in production and fleet service.
F4H - Production award winner for Mach 2+ all weather Navy fighter.
Quail - Prime contractor for air-launched Air Force decoy missile.
Utility Jet - Company is vigorously engaged in the Air Force UCX competition for a multi-purpose, 4-jet trainer-transport. McDonnell entry will be capable of going anywhere in the world at cruising speeds over 550 m.p.h.
Electronics - Development and quantity production of an electronic automatic checkout system for 101B aircraft. This system will completely check out the many electrical and electronic systems and sub-systems within minutes.
Space Exploration - McDonnell just awarded contract by N.A.S.A. to develop and build FIRST MANNED SATELLITE CAPSULE.

FUTURE OBJECTIVES - McDonnell will continue to diversify and intensify its efforts in all areas of engineering research, development and production, related to air and space vehicles for our Armed Forces.

Johns-Manville announces new **MIN-KLAD** insulation

This one new product answers 4 basic thermal and mechanical requirements



low conductivity



high heat capacity plus erosion resistance



high strength

Asbestos-reinforced plastic

Min-K insulation



New Min-Klad insulation is engineered and molded to your design requirement

Combines the capabilities of asbestos-reinforced plastic with the dramatically low conductivity of **MIN-K** insulation!

New Min-Klad insulation may well be the most significant advance ever made in missile and rocket insulation.

Developed by Johns-Manville research scientists, Min-Klad is the only product of its kind, a permanent lamination of the missile industry's two most effective high-temperature materials: 1) reinforced plastic and 2) J-M's recently developed Min-K insulation.

Does more than plastic alone

Min-Klad gives the missile designer all the advantages of high-temperature plastic: Strength, toughness, rigidity! Erosion resistance! High heat capacity! Yet Min-Klad does more.

It also insulates . . . and with dramatic effectiveness! Its insulating element is J-M's Min-K, an insulation with thermal conductivity that is lower than any other known insulation. Actually

lower than the molecular conductivity of still air. And this conductivity (already less than half that of the best fibrous insulations) drops still further with altitude. At 10 miles, for example, it is decreased by as much as 40%, with further decreases at greater altitudes.

Wide range of applications

Min-Klad offers the missile and rocket designer a rich choice of heat-control possibilities. It may be used for a part that must insulate, yet have the structural advantages of plastic. Where requirements call for a scuff- and erosion-resistant insulating surface . . . or for a good adhesive bond between Min-K insulation and other surfaces. Or, it may be used to control high transient

temperatures! For high heat capacity of asbestos-reinforced plastic combined with the low conductivity and heat capacity of Min-K result in a product that provides minimum heat transfer under transient conditions.

Min-Klad is now being tested for approximately two dozen missile and rocket designs. Why not investigate this new material for your present thermal requirements? Upon request, we'll be pleased to send you a sample of the material along with detailed technical information. Write Johns-Manville, Box 14, New York 16, New York. (Ask, too, for information on Min-K insulation and the new aviation insulation brochure IN-185A.) In Canada: Post Credit, Ontario.

JOHNS-MANVILLE

JOHNS-MANVILLE
JM
PRODUCTS

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FIGURE 2: Scatter of results with standard shear fixture (top) led to the development of the half-hole type shown below it.

also have to be given to surface finish, rolling fillets, recess configurations, and thread forms, Dickie believes.

In turn these new design problems require radically new methods of analyzing loads and fastener configurations. Hi-Shear engineers recently set up a test in which a hole was deliberately drilled off center in a plastic block. When a plastic bolt was installed and the nut tightened, the pattern in the plastic showed the distribution of bending loads. Stress concentrations in this local area could exceed the elastic limit of the material.

More and more tests are becoming necessary

In the past, only Rockwell (for 160,180,000 psi heat treat), salt spray, and zyglo tests had to be run by manufacturers. Today, specs require shear, tensile, fatigue, and metallurgical test. Even more tests — for creep-stress rupture, for in-

more on page 113

Write in No. 407 Reader Service Card

May 1959

NOW! Adjustable Diameter and Open THOMSON

BALL BUSHINGS



Adjustable Diameter
BALL BUSHING
for Zero Clearance

The BALL Bearing
for *all* your

LINEAR MOTIONS



Precision Series "A" and
Low Cost Series "B" BALL BUSHING

Open BALL BUSHING
for Zero Clearance on
Supported Shafts

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on guide rods, reciprocating shafts, push-pull actions, or for support of any mechanism that is moved or shifted in a straight line.

Improve your product! Up-date your design and performance with Thomson BALL BUSHINGS!

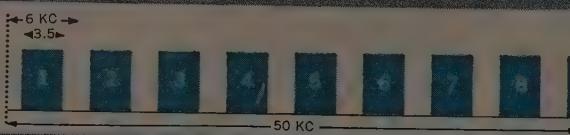
LOW FRICTION • ZERO SHAKE OR PLAY
ELIMINATE BINDING AND CHATTER
SOLVE SLIDING LUBRICATION PROBLEMS
LONG LIFE • LASTING ALIGNMENT

The various types cover a shaft diameter range of $1/8$ " to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.

THOMSON INDUSTRIES, Inc.
Dept. D, MANHASSET, NEW YORK



Also Manufacturers of NYLINED Bearings . . . Sleeve Bearings
of DuPont Nylon, and 60 CASE . . . Hardened and Ground Steel Shafting



Stretching the RF Spectrum... with Motorola SSB

Modern tactical needs for multi-channel voice and data transmission create serious communication problems within the limitations of the inflexible spectrum.

As a step toward solving this wave-length tangle, Motorola design engineers have figuratively "expanded" the spectrum by reducing the per/channel requirements in advanced portable, mobile and airborne single sideband transceivers. The result is clear, continuous and simultaneous communication in air and surface surveillance, troop movement and air support.

Motorola SSB transceivers incorporate the significant military advantages of being light in weight, compact in design. All employ these Motorola-pioneered contributions to effective communication: • Advanced application of transistors to communication equipment • Highly stable crystal oscillators • Refinements in crystal manufacturing techniques • Development and application of mechanical and crystal filters.

Motorola contracts with the three Services include pack-carried, mobile and airborne equipment.

For information on these field-tested developments—or for data on engineering career opportunities—write to: Motorola Inc., Military Electronics Division, Dept. C, 8201 E. McDowell Road, Phoenix, Arizona.



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Six Military Electronics Division plants in three locations... over 650,000 square feet of engineering and production space devoted exclusively to the design, development and manufacture of advanced military equipment.



MOTOROLA

Military Electronics Division

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stance—are indicated for the future.

Practically every high performance fastener must be made of a certified material with a certified analysis. After the material is received from the mill and inspected, it's usually sent out to an independent laboratory for a second analysis to check the mill data.

During fabrication, many fasteners require metallurgical inspection. For instance, if they are made of such materials as titanium or 431 stainless, they must be mounted and metallurgically examined for structure, grain size, and surface condition. Reports on these examinations are included with each lot shipped to the customer.

Of particular importance in future fastener tests is ingenuity in developing jigs and instrumentation to insure that the values obtained are the ones you really want. An important example is the recent development of the half-hole type of shear fixture. Interestingly enough, this jig was developed at the same time, but completely independently, by both Hi-Shear and Standard Pressed Steel, of Jenkintown, Pa.

Shear tests were hard to correlate

The need for a new shear fixture was shown by an analysis of the results of a large number of shear tests. The scatter in the results was greater than expected, and correlation between different tests was poor.

Close inspection also revealed that shearing edges broke down rapidly when used on high strength alloys. This breakdown is progressive, and any amount of it has an effect on shear results. Operators are supposed to discard any plate that shows any sign of breakdown, but, engineers note, that this practice is hard to enforce. Tests also showed that increasing side plate width didn't solve the problem.

Hi-Shear tests run on a standard shear fixture proved that the effect due to misalignment of side plates is appreciable. As Figure 1 shows, as little as 0.003 in. misalignment reduces apparent shear strength by seven per cent.

As a result, fixtures such as the one shown in Figure 2 were designed. In this case, the side plates are in one piece and only have a half-hole. This, it's claimed, insures hole alignment and keeps the part

more on page 116

work in the fields of the future at NAA



TRAINING EQUIPMENT DESIGN

The Los Angeles Division of North American Aviation—Weapon System Contractor for the nation's two most advanced manned weapon systems, the B-70 and F-108—has top-level positions available for

Training Simulator Designers

These highly-qualified engineers will coordinate and monitor the over-all design of training simulator equipment for the most advanced weapon systems projects.

Background preferred: Graduate Electrical Engineer with minimum of four years' experience in design of analog and digital computers with application to simulation requirements.

For more information please write to: Mr. P. E. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 45, California.

THE LOS ANGELES DIVISION OF

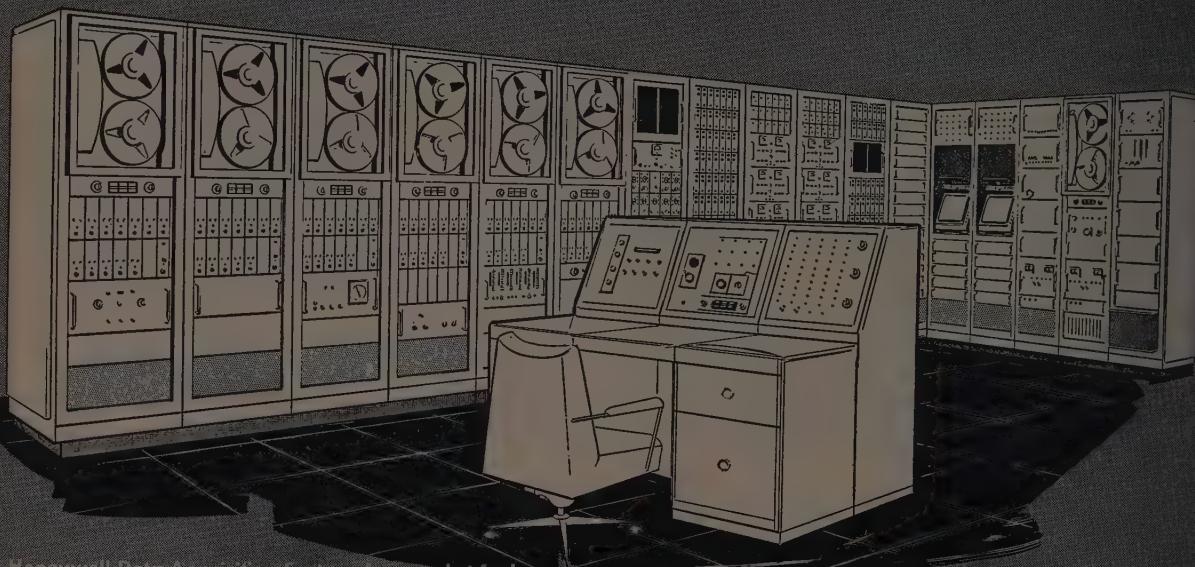
**NORTH
AMERICAN
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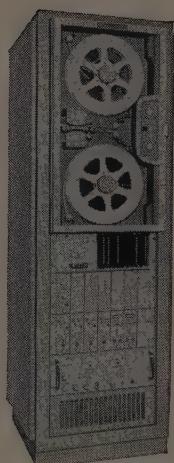
Check Employment Inquiry Form Page 155

RECORD, EDIT AND ANALYZE LARGE QUANTITIES OF HIGH SPEED DATA WITH

Honeywell



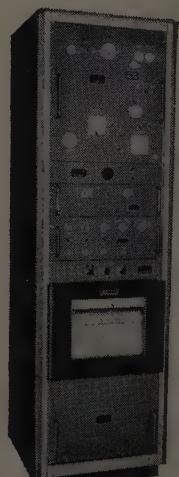
This Honeywell Data Acquisition System, for a rocket fuel test facility, has 85 low level inputs, 35 millivolt inputs. Outputs include 2 quick-look Visicorder oscilloscopes, charted analyses of analog signals, and facilities for transfer of digital data in blocks to computer tape handlers.



Honeywell Magnetic Tape Systems record as many as 40 tracks simultaneously on a single tape. The standard transports accommodate regular or thin tape, 10½ and 14-inch reels with equal ease.



Honeywell Loop Transport feeds signal to Honeywell Automatic Wave Analyzer. Playback speeds of 0.3 to 60 inches per second provide for time base expansion or contraction.



Honeywell Automatic Wave Analyzer gives a permanent, graduated chart record of amplitude vs. frequency, power vs. frequency, linear or squared reading on its *ElectroniK* recorder.

Data Acquisition Systems

Honeywell Data Acquisition Systems have what users want—reliability, speed, capacity and usable output. Each system is custom-assembled of standard Honeywell modules, to match user needs for numbers of inputs, accuracy, frequency range and readout modes. And they can be modified and expanded as requirements change and grow. All components have been proved reliable in use. Systems are delivered completely assembled, ready to connect and start up.

DATA RECORDING SECTION

Here, patchboards and panel switches provide complete flexibility in programming inputs to the recording section. Low-level signals go through the new *AccuData* amplifiers. These transistorized units have high sensitivity, and very low noise level.

After programming, the signals are fed to Honeywell Magnetic Tape Systems which have uniquely large capacity. By recording as many as 40 tracks on one tape, these systems can preserve massive amounts of data with minimum original equipment investment. Analog channels cover frequencies from d-c to 100,000 cps. Digital channels convert analog inputs and record them in whatever form, speed and accuracy is required. For example; data accuracies to within $\pm 0.1\%$, at a basic rate of 10,000 or more samples per second, are readily obtained.

DATA REDUCTION SECTION

Miles of data-laden magnetic tape are of little use until they are edited. Users of Honeywell Data Acquisition Systems are offered several options. The Honeywell Model 1012 *Visicorder* oscillograph makes it easy to take a quick look at tests being recorded or to select recorded data significant enough for further analysis. It will simultaneously chart as

many as 36 analog data patterns, showing time and quantity relations of different events. After format is programmed with selector switches, the Honeywell digital playback section selectively edits data for computer inputs.

DATA ANALYSIS SECTION

A Honeywell Loop Transport and Automatic Wave Analyzer team up to make short work of analyzing vibration, transients or other phenomena represented by complex waveforms. The Loop Transport repeats the data until the complete analysis is printed out on the *ElectroniK* recorder. Analyses that formerly took days and weeks can be done in minutes or hours.

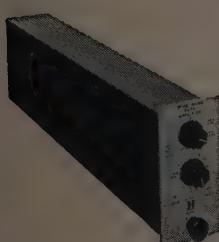
Computations on the recorded data are performed by the Honeywell *DATAmatic 800* computer. This versatile computer will process several different jobs simultaneously . . . each independently programmed and automatically controlled.

Overall and most important . . . by specifying Honeywell you get the guarantee of undivided responsibility and uniform high quality . . . one-maker systems that meet the intent as well as the letter of your specifications. For help in selecting and maintaining complete Data Acquisition Systems, there are Honeywell sales and service offices around the world, over 125 in the U.S. and Canada. Your nearby Honeywell field engineer awaits your call. MINNEAPOLIS-HONEYWELL, Beltsville, Md.

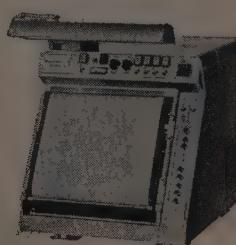
Honeywell



First in Control



Honeywell AccuData Amplifiers
give low-noise operation. Transistorized, they are inherently reliable. Seven mount across a rack cabinet.



Honeywell Model 1012 Visicorder
direct recording oscillograph will handle as many as 36 channels, frequencies from d-c to 3000 cps. It is ideal for editing analog data.



Robertshaw CAPTIVE SEAL® PRESSURE SWITCHES*

New bulkhead-mounting Robertshaw Pressure Switches represent true miniaturization for your rocket, missile and aircraft applications. Ruggedly built to withstand vibration up to 2000 cps ± 35 G's in any direction. Piston actuator is insensitive to vibration fatigue, rapid temperature cycling and extremes of overpressure. These compact Pressure Switches can be grouped on 1.09" centers . . . and even the heaviest one weighs less than 4 oz. Actual sizes are shown above.

- 50 to 600 psi pressure settings • 3000 psi proof pressure (piston bottomed against mechanical stop) • -65° to $+300^\circ$ F ambient temperature range • Vibration: 0-2000 cps ± 35 G's in any direction
- Handles combustion gases, fuel, oil, H_2O_2 , helium, etc. • Switch heads encapsulated in epoxy resin • 20,000 cycles minimum life • Weight: .240 lbs., .170 lbs., .150 lbs. (top to bottom above)

Other Robertshaw Pressure Switches are available to meet your specific requirements on mounting, electrical connections and for pressure ranges from 10 psi to 3,000 psi. Write for Data Sheet G-205.

*Design Pat. Pending

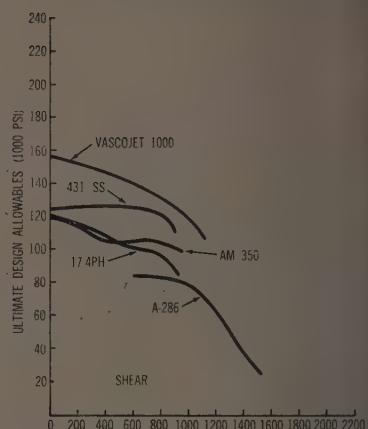
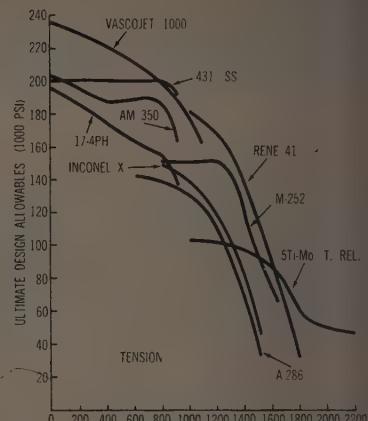


Robertshaw-Fulton
CONTROLS COMPANY

BRIDGEPORT THERMOSTAT DIVISION • Milford, Conn.

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FASTENERS . . .



DESIGN ALLOWABLES of some possible high temperature fastener materials.

from locking in the fixture. Center and side plate clearance is held to a maximum of 0.001 in. and holding the fixture in a solid block restricts deflection to 0.001 in. Figure 1 also compares the results of tests with the half-hole and the standard fixtures.

In a proposal to several major airframe companies, it was suggested that the new fixture be used as a proof load device only. A load would be selected that would be about 1½ per cent above the desired minimum. Parts would be loaded to these values and the load removed. Boeing has already adopted this method as a standard procedure.

So far as materials are concerned, in the room temperature to 900 deg F range, 431 stainless (125,000 psi yield strength), AM 350 and 17-4 (both 120,000 psi shear strength) have been among those

more on page 118

Engineers: Here are sound reasons why it pays to specify



Shelby Seamless Mechanical Tubing

USS Shelby Seamless Steel Mechanical Tubing offers you extraordinary freedom of design in a wide range of products from bushings to hydraulically operated telescoping booms. And, Shelby Seamless Tubing helps cut processing costs, because it eliminates drilling operations; enables you to replace drills with simple, less expensive boring tools, and it reduces tool wear and tool changes; and, more important, more uniform parts can be turned out by the hundreds or thousands.

Where Shelby Seamless Tubing is used as a load-carrying member or part, it exhibits a number of structural advantages over other forms.

Here are a few: it gives you a superior cross section when a part is designed to withstand equal loading in any direction; it resists bending stresses equally in all directions; it is able to absorb and localize shock; and in torsion, it provides better material distribution, and for a given weight, can withstand more load than other sections.

And, of course, the name Shelby is backed by the world's largest and most experienced manufacturer of seamless tubing—National Tube! The production of Shelby Seamless Tubing, from ore to finished product, is entirely controlled by one organization. There is no divided responsibility. Every foot, every length, is made under the careful supervision of skilled men with years of tubemaking experience. For more than 60 years, Shelby Seamless Tubing has been first with men who want the best in mechanical tubing.

You'll find Shelby Seamless Tubing available at select Shelby Distributors throughout the country. These distributors are strategically located and expertly trained in solving all types of tubing problems. Here, you can choose from a complete range of sizes and stocks. If you'd like to find out how Shelby Seamless Tubing can be most effectively applied to your designs, contact your nearest Shelby Distributor . . . soon!

USS and Shelby are registered trademarks

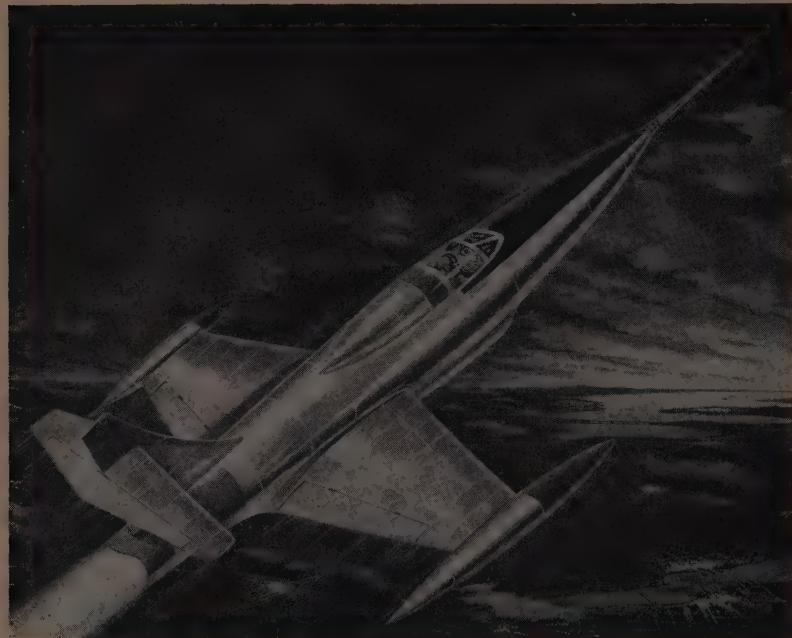


**National Tube
Division of
United States Steel**

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
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Penetrate the Thermal Barrier



Micro Mach extra-high-tensile stainless steel sheets up to 48" WIDE

for aircraft and missile use

As the speed of today's aircraft rapidly approaches the Thermal Barrier, conventional metals are being left far behind in the race to satisfy the structural requirements of supersonic craft. Needed are metals that can withstand the intense heat caused by air friction at high speeds and still retain their strength. One such metal, MicroMach stainless, has been in use for more than a year.

MicroMach is a special aircraft and missile grade of modified type 301 stainless steel sheet furnished to higher mechanical properties than are available in other commercial high tensile grades in the full hard condition.

These sheets are rolled to extremely close tolerances (as low as plus or minus 3%) with micro-accuracy and precise uniformity of gauge. The surface of MicroMach sheet is smooth, clean and dense; qualities so important in minimizing surface friction.

For further information write to
Aircraft Steels Dept.

MicroRold stainless steel is also available in all popular grades and to meet regular government specifications. Sheets up to 36" wide can be had as thin as .005", and over 36" to 48" wide as thin as .010" in all commercial finishes and tempers.



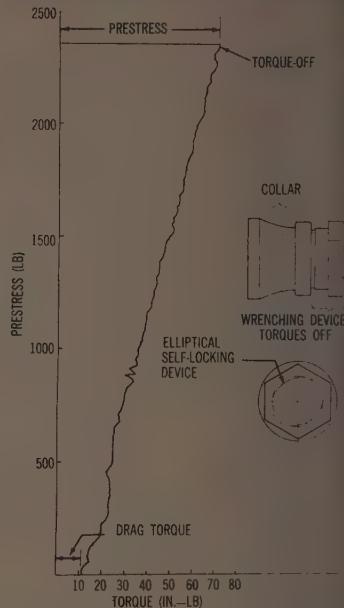
Washington Steel Corporation

5-V WOODLAND AVE.

WASHINGTON, PA.

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FASTENERS . . .



RESIDUAL stresses are measured on a Miller X-Y plotter at Hi-Shear. A transducer is strain-gaged to feed torsion and prestress data to the recorder. Typical plot is for 1/4-in.-diameter Hi-Lok fastener made of 2024T6 aluminum. Definitions: pre-stress—load built up in the fastener by the torque-off; torque-off—torque needed to remove the collar wrenching device; drag torque—torque needed to overcome the resistance of the collar's elliptical self-locking device.

used most widely. In the 900-1200 deg F range, A-286 (with 80,000 psi shear strength at 900 deg F) has been widely used. The 5Cr steels, such as Thermold J and Vascojet 1000 (with 120,000 psi shear strength at 900 deg F), look interesting but have only had limited use so far.

Coatings and platings are prob-
more on page 120



Piercing the **HEAT** **BARRIER!**

TITANIUM HUCKBOLT* FASTENERS offer up to 43% weight saving, high strength at elevated temperatures, fast installation with uniform tension and low installed cost.

Titanium Huckbolt Fasteners can save as much as half a ton per average airframe with no compromise in strength or structural integrity.

Their excellent pull-together, high clinch and swaged lock assure maximum rigidity and elimination of vibration, stripping or shake out.

Installation is so simple that inexperienced operators can install fasteners accurately and uniformly at a rate that makes other fasteners expensive and obsolete by comparison.

Removal for service or repair is simple and without work damage.

*T.M. of Huck Manufacturing Company

For complete information—write or call licensee:

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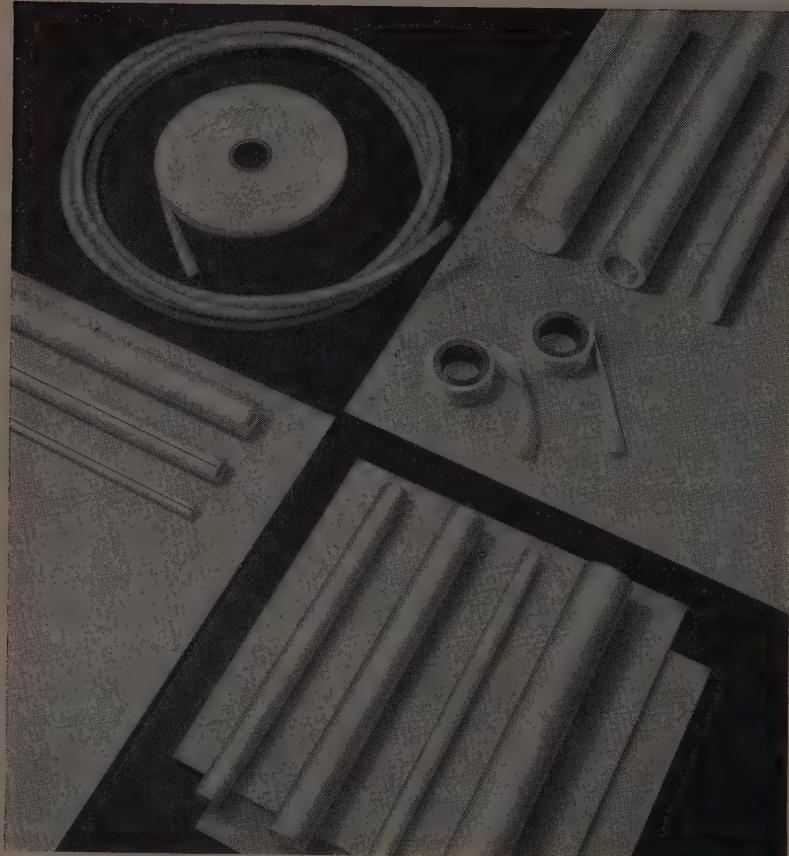
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AIRCRAFT / MISSILE DIVISION
STANDARD PRESSED STEEL COMPANY

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Jenkintown, Pennsylvania
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LOOK TO R/M TO MEET ALL YOUR TEFLON* NEEDS



R/M—headquarters for "Teflon" products. R/M can meet all your needs for sheets, rods, tubes, tape, thin-wall tubing (available with permanent color striping for identification purposes) and bondable "Teflon." R/M can also supply molded, machined and extruded "Teflon" made to your exact specifications.

"Teflon's" many remarkable properties have established it as an important material for use in aircraft, missiles and spacecraft. Yet when you select "Teflon" for a particular job, you solve only part of your problem. Equally important is the selection of a source of supply you can depend on for both competent engineering assistance and the production capability needed to meet your exact specifications and quantity requirements. This complete

"Teflon" service is yours from R/M.

A pioneer in "Teflon" application and fabrication research, R/M offers design guidance that can help assure maximum part performance, and its ample production facilities can supply "Teflon" in the form best suited to your needs. Learn more about R/M's complete "Teflon" service—and how it can benefit you—by contacting your nearest R/M district office. Or write Plastic Products Division, Manheim, Pa.

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RAYBESTOS-MANHATTAN, INC.

PLASTIC PRODUCTS DIVISION FACTORIES: MANHEIM, PA.; PARAMOUNT, CALIF.

Contact your nearest R/M district office listed below for more information or write to Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa.

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Sintered Metal Products • Rubber Covered Equipment • Abrasive and Diamond Wheels • Brake Linings
Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls

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FASTENERS . . .

lems for Thermold J and Vascojet 1000. The best corrosion protection for them is given by diffused cadmium-nickel plate.

For temperature to 1600 deg F, Hi-Shear engineers say, nickel-base alloys, such as the Inconels, M-252 and Rene 41, seem best. For over 1600 deg F, molybdenum, tungsten, tantalum and columbium are being examined.

The work in these ranges is in its early stages. For instance, engineers say, there's been a great deal of talk about Rene 41 making a good fastener material up to 1600 deg F, but little test work has been done on this application. Rene 41 sheet is fairly easily available, but headable, quality wire is limited. The materials properties at 1600 deg haven't yet been pinned down to percentages of room temperature.

A major problem is that the state of the art is changing so fast that it's hard to decide which materials to look at for extreme temperatures. Materials are expensive and it's hard to know what quality you'll get for the purposes, engineers say. All this makes it hard to get test information on which dependable design data can be based. There is some indication that molybdenum and $\frac{1}{2}$ Ti molybdenum will receive major emphasis for extreme temperature fasteners.

Experimental Ta fasteners are being made

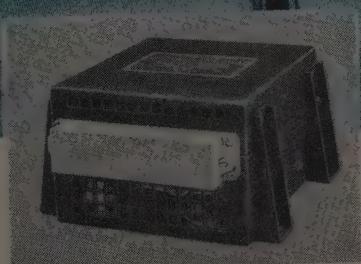
Hi-shear now is making a few tantalum fasteners for test purposes. This metal was selected over columbium because it has slightly better ductility, but CB is also slated for future tests. A major problem with all these exotic fastener materials, it's pointed out, is that manufacturing equipment and processes will have to be changed drastically.

As the exotic alloys come into view, attaching methods become critical. A material may show excellent high strength and heat-resisting properties, and then you may not be able to drive it. This means, Dickie concludes, that fastener makers may have to sell not just the fastener, but a whole new fastening system, too.—IS

PICTURE CREDITS: Cover, p. 6—Hiller Aircraft; pp. 40-42—USN, de Havilland Propellers; pp. 46-48—Fairley Aviation, NASA, Hiller Aircraft; pp. 52-55—S/A; Northrop; pp. 61-62—Northrop; pp. 67-72—McDonnell Aircraft; pp. 77-82—McDonnell; Kaman; pp. 85-90—Douglas Aircraft; pp. 99-104—USAF; pp. 107-120—Hi-Shear Rivet Tool; pp. 134-137—Convair; pp. 138-139—USAF.



Shown is the Talon T-38 trainer, developed in parallel with the new N-156F supersonic jet fighter by Norair, a division of the Northrop Corporation. When the N-156F comes off the production line, it will carry Chatham power supply 28VS100BL-1—a 100 amp, blast-cooled, silicon unit especially designed to Northrop specifications.



Chatham power supplies selected for NORTHRON space-age jet fighter!

Northrop, to secure the finest quality materials and components for its new N-156F supersonic counterair fighter, called on over 575 different manufacturers, each a specialist in a particular field. For power conversion equipment, Northrop chose Chatham.

Chatham power supplies come highly recommended for use in military fighters. Performance of Chatham units in aircraft of all types points up their extreme reliability—an assurance emphasized by Chatham's enduring reputation as a maker of trustworthy electronic components.

Another advantage—exclusive with Chatham—is in the fact that Chatham fabricates all of the solid state components (silicon, selenium, or ger-

manium) used in each unit. By strict control of component dimensions, Chatham can satisfy electrical needs, yet keep size and weight at rock bottom figures—a combination that fosters top efficiency.

You can join Northrop and the many other airframe manufacturers that now profit from the benefits offered by Chatham power supplies. Send for folder T-16 that describes stock models! Or outline your needs and we'll design and make the original unit that best meets them. Chatham Electronics, division of Tung-Sol Electric Inc., Livingston, N. J.

**CHATHAM . . . world's leading supplier of
airborne conversion equipment.**

CHATHAM ELECTRONICS
Division of
TUNG-SOL ELECTRIC INC.

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FIVE YEARS OF RYAN ROCKET MOTOR PRODUCTION



Ryan has built every production rocket motor for America's first operational guided missile

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It takes tremendous power to boost the 10-ton Corporal to Mach 3 flight speeds... to drop its atomic blast on a target 100 miles away. And this power must be controlled with pinpoint precision.

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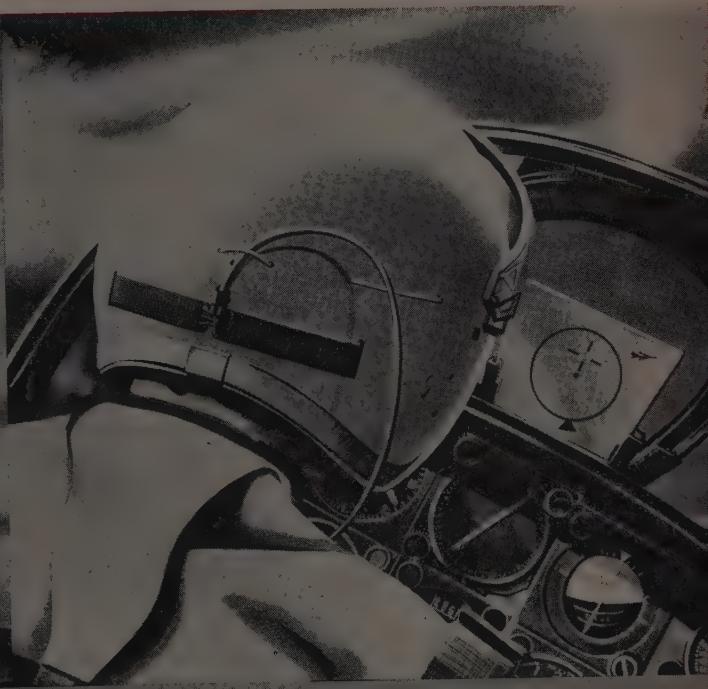
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space aero Electronics



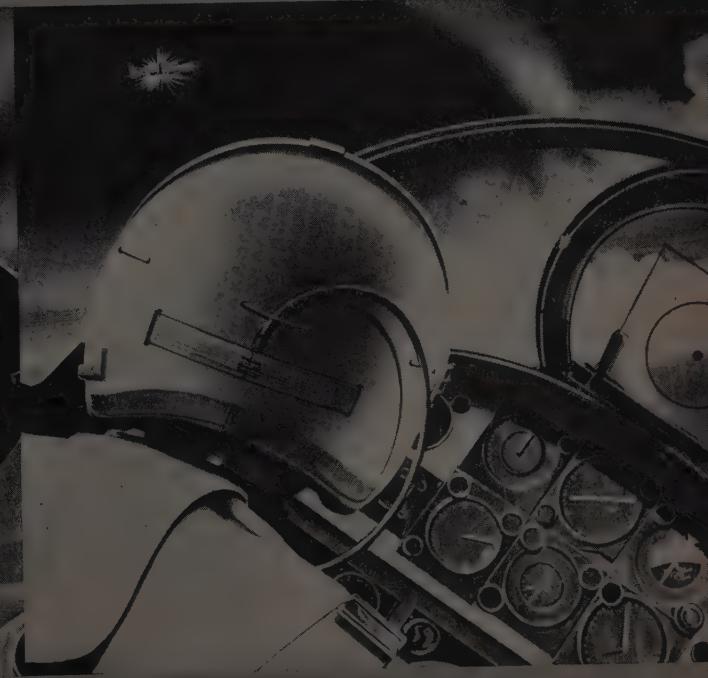
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space/aero electronics intelligence

IRE SHOW held in March in New York City turned out to be a technical flop (but set a record as the best-attended trade show in IRE history). The much publicized technical program was a bitter disappointment.

Good papers were scarce, papers with timely and *new* information were scarcer still. Many of the papers were on the technical level of "after-lunch" talks, others were "over-titled", promising more information than they actually contained.

NATIONAL IRE should take a cue from some of its professional groups and have proceedings available before the conference. This would give engineers trying to figure out what sessions to attend more to go on than scanty synopses and misleading titles. For real technical meat and up-to-the-state-of-the-art discussions, the engineer gets much more out of professional group conference in his particular area.

Panels gave little information at the IRE show

PANELS at the IRE show were especially poor from the standpoint of information dissemination. That on "Future Developments in Space" was the low point of the entire conference.

Very little was said about space electronics at all. Most of the "name" panelists seemed unprepared and totally unacquainted with the type of information their audience of some 2000 engineers was looking for. The panelist on space navigation apparently canceled out at the last minute. As it developed, the panel was dominated by two "space medics" simply because they were the only ones who had anything interesting to say.

If IRE is going to be an important group in space electronics, it had better demonstrate more technical leadership in this field.

TROUBLE with the Air Force's electronics is that it uses too many of the design and techniques evolved from "entertainment electrons," complains Col. C. H. Lewis, chief ARDC's Electronics Directorate. USAF needs 20-30 times better and more reliable equipment, he says, than that designed for entertainment purposes.

Present USAF goals, according to Lewis, are:

- To design equipment with inherent life long enough to do the job—whether it be for the short time of a missile flight or for a year-long space voyage.

- To eliminate energy-consuming components—power consumption should be in milliwatts, not watts.
- To increase greatly the number of functions per unit volume—1.5 million functional units per cubic foot should be possible.

USAF aiming far beyond Army's microminiature program

COMMENTING on the Army's microminiature module program, Lewis called it a commendable effort but still far short of USAF's goal. It is still basically a component concept, he says. USAF hopes to skip this phase of size reduction and get into "grown" molecular electronic circuits.

The ARDC electronics chief expects it will be at least four years before USAF-sponsored molecular programs will bear hardware results. ARDC is now negotiating with industry on these programs, he says.

ATOM BOMB LOGIC is one interesting program ARDC is working on, according to Col. Lewis. It is trying to develop a system that would keep a nuclear warhead from deteriorating if the bomb should veer off in the wrong direction.

ASW RESEARCHERS at American Bosch Arma believe they may have found proof of the existence of a previously unknown radioactive field that can be detected, generated, and controlled. Their finding is based on physical theory and mathematics, not on experiments.

THIN-FILM solar cells would be a breakthrough in the state of the art, claims Dr. W. J. Vander Grinten, of GE's Research Labs. They would cut weight and probably cost, too, making solar cells decidedly more practical. (Today it takes about a

more on next page



Cover story—GE's optical sight used in missile-firing F-104 automatically computes lead angle from radar range, plane's speed and altitude, and angular motion sensed by its gyro. Range marker moves ccw as plane closes in. Glass plate combines display and optical sighting.



space/aero electronics intelligence

pound of silicon cells to get five watts output. Cost is around \$500). So far no one has figured out a way of making the solar films, Vander Grinten says.

AIRBORNE ATOMICHRON in development at National Co., Malden, Mass., weighs some 60 lb, puts out a 100-kc signal with stability of one part in 10^{-9} . It will warm up in 30 minutes and operate under Mil-E-5400 conditions. WADC has contracted with National for a 23-lb, one-cubic-foot version of the atomichron for use in missiles.

Power supply for Atlas puts out two kva

ATLAS' transistorized power supply, in pre-production phase at Varo, can put out two kva. The three-phase, 400-cps supply has a regulation of one per cent in voltage and 0.1 per cent in frequency.

FIRST "CHEAP" GYRO ever made by Minneapolis-Honeywell has a gas-driven rotor. The gas is contained in a cartridge. At a present moment a knife automatically comes down and chops off the neck of the cartridge, releasing the gas to drive the rotor.

The gyro is used for short range missiles.

ELECTROSTATIC gyro progress at Minneapolis-Honeywell has been unusually good in last six months, according to a company spokesman. Now M-H foresees the use of this gyro "in places heretofore felt impossible."

ESG has been in the works for three years at M-H under sponsorship of BuShips and with the assistance of the Office of Naval Research. It will be M-H's first two-axis gyro. (GE, too, is reported to have an electrostatic gyro.)

Librascope guidance system for anti-sub missile

ASROC anti-sub missile, to be launched from surface ships, will have a new guidance system built by Librascope. Presently there are two Asroc versions: one uses a torpedo warhead and acoustical guidance, the other a depth-charge-type detonation system. Some 400 Asrocs have already been fired—all from land.

PIASECKI AIRCRAFT jumped into electronics with both feet in when it bought an electronics

plant at Mayfield, Pa. The new Piasecki Mayfield Electronics Div. is geared for production of nucleonic, electronic, and electromechanical assemblies.

TITAN ICBM will get all-inertial guidance system under a contract just let to AC Spark Plug by USAF. The system will be based on basic research done by MIT.

Earlier contracts for Titan radio-command guidance system still hold good, however—this equipment will be installed in the missiles going to the early Titan squadrons.

RADIO-COMMAND guidance system for the Titan has an "extra-ordinary degree of invulnerability to both friendly radio interference and intentional enemy electronic countermeasures," boasts Bell Labs. Bell is teamed with Remington Rand-Univac on the guidance system. It makes the radio and radar and Rem-Rand the system's Athena transistorized digital computer.

FAA will close down TDEC's Indianapolis facilities

ONE of the finest teams in aviation electronics history will be disbanded when FAA closes down its Technical Development & Engineering Center at Indianapolis, Ind., around July 1. FAA will take many of the technical specialists into its development groups at Washington, D. C., and Atlantic City, N. J.

FACILITIES OF TDEC may be taken over by Hazeltine Electronics for use as IFF and AEW test and development area. Hazeltine has just about concluded negotiations with the city of Indianapolis for a lease. The facility includes an airstrip, which would be extremely useful in the IFF and AEW work.

Some 40 engineers from TDEC have signed up with Hazeltine and will remain at the Indianapolis site. If the deal goes through Hazeltine would form new subsidiary.

Hazeltine also has plans for sizeable expansions of its home facilities in the New York area. The company did some \$62 million in electronic sales last year.

DOPPLER OMNIRANGE might be the answer to VOR site errors. According to extensive tests made by FAA on several difficult sites, Doppler omni has cut scalloping and course

more on page 128

Pulse Repetition Rate to 10 Mc!



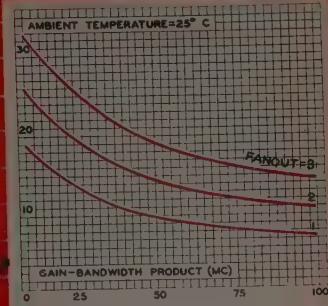
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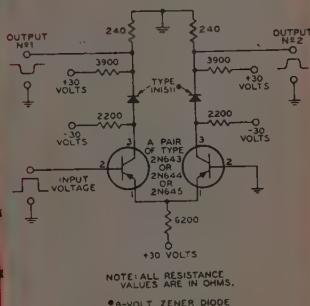
RCA-2N643, RCA-2N644, and RCA-2N645 feature controlled minimum gain-bandwidth products, of 20, 40, and 60 Mc

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Curves illustrate typical delay time per stage vs. gain-bandwidth product and fanout for the switching circuit shown below.



TYPE	2N643	2N644	2N645
Minimum gain-bandwidth product* Mc	20	40	60
Minimum collector** breakdown volts	30	30	30
Minimum DC current transfer ratio*	20	20	20
Maximum collector capacitance μuf	5	5	5

*Collector Volts = -7, collector ma = -5

**Collector Current = 100 μa

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errors by factors as high as 20. Tried out on good VOR sites, the improvements were least 6:1.

VOR Doppler is compatible with airborne receiving equipment, but the VOR ground station would be substantially different. FAA is already thinking in terms of using the system at some 50 difficult VOR sites throughout the country.

VOR DOPPLER was invented by Paul Hansel, chief radio engineer of Servo Corp. of America, back in '45. Hansel and Servo have been pressing for its acceptance ever since. Some of the technical people at Servo and within FAA claim that, had Doppler omni been accepted years ago, the entire VOR-Tacan controversy would have been avoided. They point out that the big advantage of Tacan over VOR is that Tacan has far less site error—yet Doppler VOR already reduces site errors to negligible values.

34 million components per cubic foot with semiconductor solid circuits

SEMICONDUCTOR solid circuits were demonstrated by Texas Instruments at National IRE show. TI starts with one base material (silicon or any semiconductor) and out of it forms diode, transistor, resistor and capacitor elements. It has already made multivibrators about the size of the head of a match. Component densities ranging up to 34 million components per cubic foot are possible with this technique, says TI. It is now working on specific circuits for "undisclosed customers" (believed to be some of the large missile system producers).

Lockheed and most other systems manufacturers are known to be exceedingly interested in solid state circuits. Lockheed has already hired Dale Fuller, one of the nation's top molecular electronic scientists, from Varo.

THERE'S NO reason to build better inertial devices for operation outside the atmosphere, claims Bob Maze, head of inertial sensor research at Minneapolis-Honeywell. Undersea warfare and missile guidance still need more precise inertial systems, but what we have now will do for space vehicles, he says.

Problem in inertial systems for space vehicles, claims the MH researcher, is adapting what we have to the vehicles and building new devices for space along conventional lines.

INFRARED as a means of detecting and homing weapons against enemy subs is being studied by several firms and research groups with both AF and Navy support. One technique that has been mentioned is the detection of hot patches of ocean on or near the surface said to exist while a sub is in the vicinity and for a brief period after it has passed. One engineer questioned by SPACE/AERONAUTICS probably voiced the opinion of most when he guessed that, as things stand now, sonar is better than IR for detecting submerged subs.

UNDERWATER use of IR is probably out, because of the ocean's killing attenuation of any heat radiation. Rumor has it the Navy is pressing research into other new and exotic underwater detection media.

Two novel approaches are reportedly also being sought for improving the effectiveness of present techniques:

- changing the condition of an ocean area to support detection better,
- producing changes in an ocean area that would in some way make any sub in it a better target.

MIT LINCOLN LABS' successful Venus contacts with its Millstone Hill, Mass., radar largely depended on a solid-state maser used as a low-noise amplifier. This was not only the first known use of such a maser in a practical system but also the first at frequencies as low as the lower UHF band. The Millstone Hill radar operated at about 300-500 mc, with a pulse power of 265 kw.

THE MASER is a crystal of chromium-doped potassium cobalticyanide. Reportedly it gave the radar receiver a noise improvement of a factor of four.

According to one of the scientists at the radar site, the maser had a noise temperature of 70 deg K. Added to the extraneous noise, this gave a total noise temperature of 170 deg K while looking at Venus.

The signal to be amplified was coupled into the crystal through a tuned lead-wire loop encircling it. Power was then pumped into the crystal via the cavity at 5400 mc (much higher than the signal frequency). The signal was returned from the crystal by way of the same wire loop, amplified by a factor of 325 (25 db). Subsequent amplification was through conventional stages.



REFUELING MISSION ACCOMPLISHED WITH BENDIX-PACIFIC RADAR BEACONS

All-weather refuelling of B-58 bombers by KC-135 tankers will soon become Standard Operating Procedure through the electronic teamwork of such products as the Bendix-Pacific Rendezvous Beacons. Bendix-Pacific has developed these beacons in cooperation with the Fort Worth Division of Convair, the Transport Division of Boeing Airplane Company and Wright Air Development Center, and will shortly be producing these rendezvous beacons in quantity.

Bendix-Pacific maintains a complete staff of airborne radar personnel to assist you in the solution of your problems.

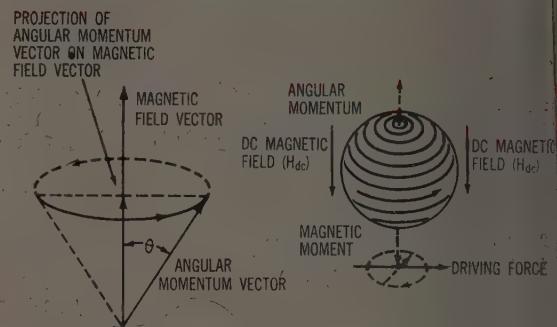


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CHARGE, MASS, AND SPIN of electron results in angular and magnetic moments (right). When atoms are placed in magnetic field, electrons—because of their magnetic moments—experience orienting torques. The constant field H_{dc} furnishes a definite reference direction in space for magnetic and mechanical vectors of the particle. Left: Torque due to magnetic field causes total angular momentum vector (\mathbf{p}) to precess about direction of magnetic field as an axis, always keeping same inclination angle θ . Vector has projection (p_x) on magnetic axis so that $p_x = p \cos \theta$. Magnetic field quantizes atoms so as to keep constant the component of angular momentum (p_x) in field direction.



Researchers explore **exotic gyros**

by James Holahan, Electronics Editor

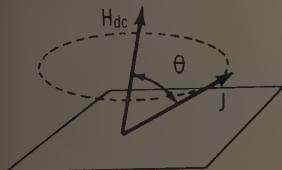
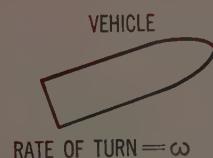
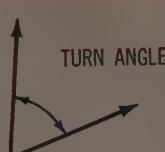


The use of the gyromagnetic properties of electrons and nucleons for rate and displacement sensing has long been a favorite conversational topic among inertial component and system engineers. Now, in a serious effort to replace the gimballed spinning wheel configurations, many government and industry research programs are looking into the possibilities of the particle gyro.

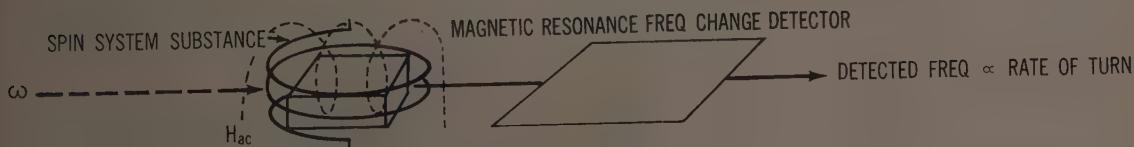
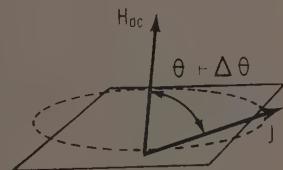
THE ESSENTIAL JOB of a gyroscope is to establish a frame of coordinates in space, so that we can either find the rate of motion relative to that frame or make sure the frame is fixed and stays fixed in space. The gyroscope problem therefore boils down to putting Newton's laws or their quantum mechanical equivalents into hardware.

In "inertial quality" gyros we seem to have about reached the limit of present techniques. In the best operational gyros, random drifts have been cut to around 0.01 deg/hr by milking conventional design, machining, and assembly methods to just about their practical limits. Further improvements along conventional lines require an inordinate amount of work for minute performance gains.

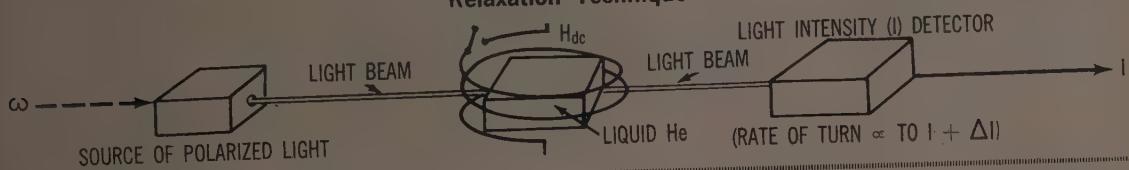
CRITICAL TOLERANCES demanded by inertial-quality gyros tax machining and assembly skills and techniques. New sensing schemes are definitely needed.



Gyromagnetic Resonance Technique



Relaxation Technique



PARTICLE GYRO: Simple classical theory of two methods being worked on for particle gyros. Drawings show operation for each only in one plane. Actually both techniques would use three mutually perpendicular systems to sense the three components of angular velocity. Both techniques are based on quantum mechanics, but because of the large amount of molecules even in a

small quantity of the substance (gas, liquid, or paramagnetic solid), detecting the rate or amount of turn becomes a statistical problem and so can be described in classical terms. In detecting frequency, for example, there are no quantum jumps (as there would be with single particles)—the change of frequency is continuous.

Long aware of this problem, the military and the gyro designers have been searching for completely new approaches that might bring improvements by a whole order of magnitude. Most "exotic" is the idea of using rotating atomic particles instead of the conventional gyro rotor.

The basic problem here is to harness the inherent angular momentum of protons or electrons that have been spatially oriented, or "quantized", by an applied constant electric or magnetic field. The particles, because of their motion and charge, have both mechanical and magnetic moments. These moments give the particles the two fundamental properties of gyros around which are built most guidance, navigation, and stabilization systems: precession and rigidity in space.

The "particle" gyro does not depend on just a single particle for its operation, rather large groups of particles in a substance are used to produce gyro-magnetic properties on a detectable level. Microscop-

ically (from a single-particle viewpoint) the device follows the laws of quantum mechanics. Macroscopically, however, it behaves, because of the statistically predictable nature of a large number of particles, like conventional gyros, according to Newtonian concepts.

The particle gyro is really one of the first practical applications of quantum mechanics. For this very reason gyro researchers are handicapped—there are many gaps and unproven assumptions in this new field. However, according to theoretical calculations by several study groups, partical gyros with random drifts of 10^{-8} to 10^{-4} deg/hr are possible.

It is fairly well established that the nucleons (protons and neutrons) and electrons of an atom possess angular moments, since they orbit around a central axis and spin around their own axis. Much more is known about the electronic structure of the atom than of the atomic nucleus. However, electronic concepts have been applied to the nucleus (in the form of the

more on next page

The Particle Gyro—A Controversial Topic

Most gyro developers agree that we need bold new ideas if we are ever to get "order of magnitude" improvements over conventional gyros. There is much less agreement, however, that the particle gyro represents a worth-while effort in this direction. Generally the more hardware-minded people think the particle gyro is a fascinating device that will never work. The research-oriented people—even within the same company—agree that only lack of engineering effort is holding back the particle gyro.

WADC apparently is enthusiastic. But one leading precision gyro maker thinks Wright Field officers are technically not qualified to judge the merits of particle gyro projects and are throwing away taxpayer's money on "blind-alley" research.

There are probably over a dozen military-sponsored research projects in the particle gyro area. All are relatively small, and some are funded with money "borrowed" from weapon systems. According to a reliable

industry source, a total of about \$1.5 million is tied up in R&D on exotic gyros.

General Precision Labs and Maxson, both working under WADC contracts, are confident they will at least be able to prove that the principles on which their particle devices are based are sound. AC Spark Plug, Arma, Autonetics, Hoffman Labs, Martin Co., Minneapolis-Honeywell, Motorola, and Sperry are also studying particle gyro phenomena.

Arma especially has been quite active in "blue-sky" approaches to inertial sensing. Its research has probed into devices based on the interaction of charged particles with electromagnetic fields to create inertial effects; hydrodynamic gyros; the interference of particles in inertial space; magnetohydrodynamic gyros; relation gyros, using solid state samples; elastic gyros; and particle gyros. According to Arma, hydrodynamic and elastic types look more promising than any other gyro it has investigated.

First Practical Use of Relativity

Maxson calls its particle gyro an "ElectroMagnetic Inertial Rate" (Emir) type, "expected to be purely electronic in nature and employ[ing] no moving parts" to sense angular rate of motion.

The Emir principle is based on the interference properties of electromagnetic waves in an accelerated frame, the acceleration being caused by the rotation of the frame. As such, claims Maxson, this "phenomenon be-

longs to the sphere of the principles of general relativity, and it is believed that the successful development of Emir will be the first known practical use of this theory."

Emir has potential use in all types of vehicles, but is earmarked in particular for space navigation and guidance, says Maxson. Wright Aeronautical Development Center's Weapons Guidance Lab is the contracting agency.

nuclear shell model) and appear to hold for it as well as for the atom.

Completed electron shells in an atom have no net angular momentum, for the orbit moments neutralize one another, and so do the spin moments. Only the electrons outside closed shells contribute to the total angular momentum of the atom. This shell concept is believed to hold for the nucleus also. Because only "open shell" atoms and nuclei contribute to the total angular momentum these are the ones used for particle gyro experiments.

Electrons develop magnetic moments

Because of their charge and motion, the electrons develop magnetic moments, too. These—expressed in Bohr magnetons (each equaling 9.27×10^{-21} erg/gauss)—are larger than the corresponding angular moments. Because of their negative charge, they are also opposite in direction to the corresponding angular momentum vectors. In the presence of a magnetic field, the resultant vectors (angular and magnetic) will precess about the field vector (see *Schematic*).

According to the so-called Larmor theorem, the angular velocity of the precessing vector is:

$$\omega = (e/2mc)H = (\mu/p)H$$

and the frequency of precession is:

$$f = (e/4\pi mc) = (\mu/2\pi p)H$$

where e is electronic charge (in esu); m , mass of the particle; c , velocity of light; μ , magnetic moment vector, p , angular momentum vector; and H , constant

magnetic field. The angular momentum is in $h/2\pi$ units (h being Planck's constant). The ratio μ/p is called the gyromagnetic ratio. Its value for particles ranges from six to -0.3 ; for protons and electrons it is about 5.3.

The angular and magnetic moments of the nucleus are the vector sum of the individual nucleon angular and magnetic moments, respectively. Like the electron, nucleons have both orbital and spin moments and are quantized by a constant magnetic or electrical field. When quantized, they precess about the field vector at the Larmor frequency.

Precession is easier to detect with protons than with electrons, say researchers. For practical magnetic field strengths, the proton's precessional frequency is in the megacycle range. (In a field of 12,000 gauss, proton precession in hydrogen would be 40 mc.)

The proton also has the advantage of 1840 times more mass than the electron, which makes it the larger "gyro rotor." The electron, because of its smaller mass, has a precession frequency in the millimeter and sub-millimeter range.

As with conventional gyros, the types of particle gyros that are being worked on depend on either precession or rigidity in space. The former property naturally lends itself to rate gyros. Any imposed external angular momentum vector—such as that imposed by a turning vehicle—vectorially adds to the particle's own angular momentum vector. The magnetic moment likewise changes. This in turn changes the Larmor frequency proportionally to the rate of turn.

The new frequency can then be detected by the magnetic resonance or absorption methods now used by physicists for measuring electronic and nuclear moments.

To detect the rate of turn about all three axes of a vehicle, three mutually orthogonal particle gyros would be needed.

The second type of particle gyro uses the rigidity of molecular spin states in liquids and gases. Molecules possessing magnetic or electric dipole moments are aligned by application of a constant electric or magnetic field. The field is then removed so that the vehicle is free to turn about these fixed spin axes without disturbing them. However, once the field is removed the dipole moments tend to "relax" into their original disoriented state of random thermal motion.

Because this return is caused by the various particle motions within the atom, lowering the temperature to cryogenic levels slows down the process, or extends the relaxation time. Samples at liquid helium temperatures have relaxation times of a few hours, researchers report.

Molecules "memorize" their direction

The purpose of the long relaxation times is to let the molecules "memorize" their direction in space for a usefully long period. The spins could be affixed to space coordinates by aligning them originally with a distant star. In a similar manner they could be indexed to serve as a reference for any set of coordinates. So oriented, the gyro could be used to measure both displacement and rate of displacement.

In one particle gyro type that is being worked on, liquid helium is used as the sensitive substance. It is quantized by a magnetic field, and then the field is quickly removed, leaving the fixed orientation of the dipoles dependent on their rigidity properties.

Sensing in some instances is being done by sending a source of polarized ultraviolet light through the spin system. The original polarization would be aligned with and fixed to a particular axis of the vehicle. As the vehicle turns, the spin would tend to keep its fixed orientation, but the angle the polarized ultraviolet light makes with the spin system would change as a function of the amount of turn (or rate of turn, depending on how the detector would be arranged). Because of the different angle of intersection of light and the molecules, the intensity of the light would also change as a function of the amount (or rate) of turn.

Since the spin system tends to precess back into a random state, such a gyro obviously would have a limited useful life unless it were recalibrated periodically. Cryogenic temperatures would prolong the alignment time as well as the relaxation time. Some of the groups that have looked into this problem suggest using two gyro systems—one "uncaged" (i.e., aligned and then freed of the aligning field) and operating and the other "caged" and subjected to the aligning field and kept in standby. The pilot would use the two alternately.

As with the precession type, three systems would be needed for sensing in three dimensions.

Perhaps the key problem of particle gyros is detecting the minute radiations that accompany accelerations to the particles caused by changes in the motion of the vehicle. The effects are microscopically small and subject to disturbance on atomic, nuclear, and

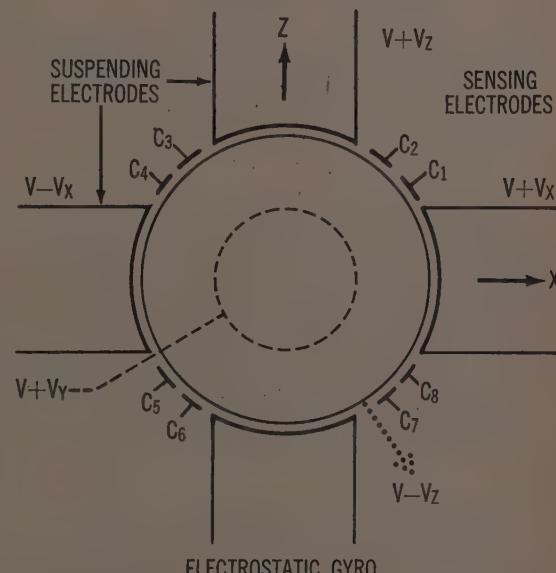
thermodynamic levels. It all adds up to a terrific signal-to-noise ratio problem. For example, for the magnetic-resonance method of detection, one researcher calculates, the induced output voltages indicative of resonance would be in the microvolt or micro-microvolt (10^{-12}) range.

Where rate of turn is the desired parameter, for instance, the problem is essentially one of detecting a few cycles (corresponding to vehicle rate of turn) in tens of megacycles (for proton precession) or many hundreds of megacycles (for electron precession). Because of the large ratios involved and the limitations of instrumentation, the higher the magnetic resonance frequency, the worse the sensitivity.

Among the many and varied approaches to particle gyros design that are being tried out, the two major appear to rely on the detection of proton precession and the use of "relaxed" spin states, respectively. Water is being used by some groups as the active element—or rather the single proton in each hydrogen atom (the oxygen atom doesn't play any role). Other substances that are being used are elements with incomplete outside shells.

For solid substances, diamagnetic and paramagnetic elements are used rather than ferromagnetic ones. The latter suffer as particle gyro substances because they do not leave the particles free to align with the field (neighboring particles interfere).

Some groups are trying to accelerate particles to relativistic orbital velocities. Here the angular momentum of the particle would be greatly increased, both because of the higher speeds and because of the mass increase according to the Einsteinian relationship between mass and velocity.—End



ELECTROSTATICALLY suspended gyro: The spherical rotor is suspended between three pairs of support electrodes. Sixteen other electrodes form capacitances C_1 , C_2 , etc., with the rotor. These serve to detect direction in three-dimensional space.



AZUSA tracker at Cape Canaveral.

Azusa

predicts ballistic missile impact points

Originally designed as the basic guidance system for the Atlas, the phase comparison Azusa system now is the prime tracker for most ballistic missiles fired at Cape Canaveral. Coupled with an IBM 701 and plotting boards, it predicts the impact points for all these missiles.

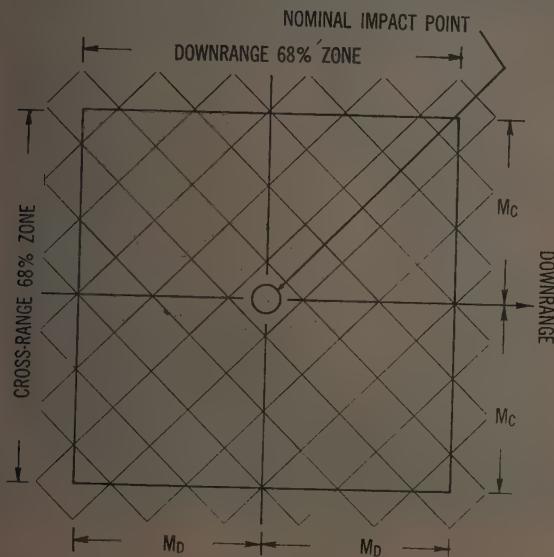
by S. L. Ackerman and R. C. Weaver

Senior Project Engineer & Design Specialist, Convair-Astronautics¹

THE IMPACT POINTS of ballistic missiles launched from the Air Force Missile Test Center (AFMTC) at Cape Canaveral, Fla., can now be accurately predicted. An electronic tracker-computer-display system continuously predicts the point at which the missile would impact if thrust were cut off at the time for which the prediction computation is made.

Previously radar plots were used to show the present position of missiles during test flights. This scheme only worked for relatively slow, aerodynamic birds, such as the Matador and the Snark. Their low speed left ample time for range safety action in case they went astray. Besides, since the free-fall trajectory after power cutoff of missiles with lift surfaces cannot be accurately analyzed, no serious attempt could have been made to predict an impact point for such vehicles.

¹ Convair-Astronautics Div., General Dynamics Corp., P. O. Box 1128, San Diego 12, Calif. The authors wish to acknowledge the help of the Convair-Astronautics Flight Performance Analysis Group and specifically that of Dr. R. M. Leger and Messrs. M. Blum, H. Gottschalk, and P. Henry.



AREA of 47 per cent hit probability. M_c and M_d are RMS values of dispersions due to random noise in the tracker data.

The prime reason for an impact predictor (IP) is range safety. A second, closely related factor is that an accurate IP allows narrower destruct corridor limits. For example, if the impact has to be close to instrumented and inhabited areas, then a low accuracy tracking and IP system require large safety margins outside the absolute destruct corridor limits. If the system is accurate enough to give the range safety officer (RSO) a great degree of confidence in the indications of actual missile position and consequently the predictions of impact dispersions, then the corridor limits may be narrowed without compromising range safety.

The required tracker accuracy is directly related to the allowable impact dispersions. If larger impact areas and wider flight corridors are permitted, then tracking data can be less precise.

If one had the entire Atlantic Ocean as the impact area, impact prediction would be easy. The vehicle would merely have to be tracked to make sure it was programmed properly and was traveling towards the ocean. Except in the case of a complete turn-around, this would be enough to meet the range safety requirements.

From this extreme we may go to the case in which the missile must pass close to inhabited areas or the impact point must be near instrumented sites or in a small recovery area. Here it is desirable to narrow down the flight corridor to limits that can be readily described from a tracking and prediction standpoint but still give the RSO adequate destruct margins for protection of life and property.

Normally the accuracy requirements are related to the ability to smooth the data so as to reduce dispersion. Unfortunately, normal smoothing techniques introduce time delays that may become intolerable for high

speed vehicles. A compromise usually has to be made between maximum accuracy and minimum delay.

In tracking from behind the launching site, the more demanding parameter is radial velocity, rather than angular velocity or position information.

The dispersion of the predicted impact point caused by dispersions in the tracking data can be resolved into cross- and down-range dispersions. Dispersion due to random noise in the tracker data are represented by root mean square values M_c and M_d , respectively. M_c and M_d represent dispersions due to bias in the tracker data.

One-sigma dispersion values used

Since M_c and M_d are computed as the one-sigma² values of impact dispersions, there is a 68 per cent probability that all impact points will be in a zone $2M_c$ wide that brackets the locus of nominal impact points. A similar situation exists for a zone $2M_d$ wide that brackets the true impact point (corrected for delays caused by smoothing and computing time).

The area contained in both these zones has the dimensions $2M_c$ by $2M_d$. The probability of an impact prediction's falling in this zone is about 47 per cent (see Schematic). If three-sigma values are used, then the area with the dimensions $6M_d$ by $6M_c$ gives a 99 per cent probability.

Values of cross- and down-range dispersions have been computed for three fictitious missiles with impact ranges of 150, 1500, and 5000 miles. Azimuth and elevation angle and range data of three different qualities were assumed. The one-sigma values (σ_A , σ_B , σ_C) of the poorest position data for tracker A were 0.25 milliradians (with no cross-correlation) in azimuth and elevation and 25 ft in range.

Tracker B was assumed to have one tenth as much dispersion of angle and range data as A. Tracker C was assumed five times better than B. The results of these calculations are given in Table I, for the three fictitious missiles. One-second midpoint smoothing was used in deriving velocity from position, and one second was used on the position data.

Smoothing time vs dispersion

Additional data showing the effect of increased smoothing time on impact point dispersions are given in Table II for the 5000-mile range. In this example, tracker A is used with one-, two-, and three-second smoothing periods. Appropriate changes in the order of the curve-fitting polynomial were applied as the smoothing time was increased. Midpoint smoothing was used in all cases. This results in a time delay equal to half the smoothing interval plus any delays due to computing and display procedures.

Total dispersion caused by bias and random errors in data is the root sum square of the values of dispersions for bias and random noise considered separately. Table III shows the dispersion components M_c and M_d caused by bias errors that are equal to the one-sigma values of random error for trackers A and B.

(2) A term from probability theory standing for the standard deviation, defined as the RMS value of the deviations of like quantities from their mean value.

more on next page

IMPACT PREDICTION plotting boards in the computer room at Cape Canaveral. Made by Electronic Associates, the boards are Vair-plotter types.



Total dispersions TM_o and TM_D are the root sum square of their components M_o , \bar{M}_o , M_D , and \bar{M}_D :

$$TM_o = (M_o^2 + \bar{M}_o^2)^{1/2}, \quad TM_D = (M_D^2 + \bar{M}_D^2)^{1/2}.$$

Thus it is not worth while to make the error due to random noise much less than the error due to bias.

Long smoothing intervals with midpoint smoothing result in prediction data that is late by half the smoothing period plus computing and data handling time. In the case of an ICBM, in which impact range may change by as much as 200 mps near burnout, this can be serious.

Endpoint smoothing can considerably cut the delay, but at the cost of increased dispersion and considerable overshoot of the predicted impact point immediately after actual thrust cutoff. A better approach is to use a system with sufficiently low random and bias errors to permit use of smoothing intervals of about one second.

Guidance system can't be used

To provide high accuracy tracking information, one of the first data input systems we considered was the guidance tracker itself. Unfortunately, this didn't solve the problem, because of one or more of the following limitations:

- During the R&D phases, guidance equipment is not normally available.
- Missiles using all-inertial guidance systems would not provide tracking data.
- Under the weapon system concept, the accuracy requirements imposed on a guidance system may be less severe than those required for AFMTC impact prediction.
- If the R&D guidance system should fail in flight but it can be shown by good tracking instrumentation that the missile still remains on a safe course, then the flight could continue, providing as much telemetered inflight and re-entry data as possible.

Currently Convair's Azusa precision tracking system

provides direction and range data at AFMTC that has about the same accuracy as the Tracker C example we have cited. Azusa cannot be described in detail for security reasons. It is a microwave system using short, crossed baselines to provide angular measurements based on phase comparison of a signal received on the ground at moderately separated, accurately surveyed antennas. Measurement of carrier modulation frequency shift is used for range determination. The system is unambiguous, and, at present, velocity is derived from the range data through difference equations. However, recently installed modifications will provide radial velocity to a much higher degree of accuracy by Doppler shift measurement of the carrier.

Data obtained from Azusa are fed to a high speed digital computer. The impact points predicted throughout the flight are displayed on a plotting board. At first, we thought of building a special device for this special computation. The urgency of the task at the AFMTC ruled out this approach. Instead, several general-purpose computers were investigated, and the IBM 704 was selected because it came closest to our requirements.

Computer stores refraction data

A true ballistic missile falls in a very predictable trajectory. For accurate impact prediction, one must know, among other calculable parameters, the position and velocity of the missile at the end of the powered portion of the trajectory. The computer must convert the Azusa tracking system's geodetic rectangular coordinates into geocentric coordinates. Velocity is computed in geocentric coordinates from the position data.

The computer also stores atmospheric refraction corrections; this data is appropriately programmed in relation to elevation and slant range. A reasonableness check has also been included to validate the tracking information. This is a cross-check technique that compares previously derived points with the new point. If the new point appears to be erroneous—for example,

Table I: Impact Dispersion vs Random Data Error

Tracker	Data Dispersion	Impact Dispersion (miles)					
		150 Miles Impact Range		1500 Miles Impact Range		5000 Miles Impact Range	
		M_C	M_D	M_C	M_D	M_C	M_D
A	0.25 mil 25 feet	2.19	1.34	25.2	10.33	71.1	106.1
B	0.025 mil 2.5 feet	0.22	0.13	2.52	1.03	7.1	10.6
C	0.005 mil 0.5 feet	0.044	0.026	0.50	0.21	1.42	2.1

Table II: Impact Dispersion vs Smoothing Time (5000 miles impact range)

Tracker B Data Smoothing Time	Impact Dispersion (miles)		Tracker	Bias	Impact Dispersion (miles)	
	M_C	M_D			M_C	M_D
1 sec	71.1	106.1	A	±0.25 mil ±25 feet	0.82	0.16
3 sec	14.9	23.9				
10 sec	6.3	9.6	B	±0.025 mil ±2.5 feet	0.082	0.016

if the velocity has been radically altered—then the point is rejected and not used in the computation. This feature is particularly important for long range ballistic missiles.

The computer output is the latitude and longitude of the predicted impact point. Ten computations of impact point are performed per second. Computing time is approximately 76 milliseconds.

Display is on an Electronics Associates 205J plotting board with a 30x30-in. chart. A scale of 1:48,000 is used for the early portion of flight and one of 1:500,000 for the latter portion for missiles impacting not more than 200 nm from the launch pad. Longer range trajectories may be handled either by use of layback methods (i.e., retracing across the charts) or with more plotting boards. However, even with four plotting boards, rescaling becomes necessary for longer ranges, and plotting scales of 1:750,000, 1:2,000,000, 1:2,500,000, and 1:4,000,000 have been used.

More boards for greater precision

The use of more boards with precision offsets and expanded plotting is preferred when high accuracy is required. The advantages of scale expansion are limited by the high rate of change of impact range near burnout for a long range missile. For example, if four plotting boards were used with 1:2,000,000 scaling, each covering 1000 nm of the predicted impact point path, one could get a plotting board error of about one nautical mile for the entire flight.

In multiple plotting board installations, provision is

made in the computer programing and memory for the offsets, scaling and switching of the predicted impact data. When the scales of the plotting boards are different, a section has to be provided in the computer routine that automatically changes the scaling of the output numbers, for instance at a chosen value of longitude.

Special subroutines insure positive shifting of scales in the presence of noise. Originally, plotting boards for interim IP use were manually shifted at preselected longitudes, corresponding to the points at which computer routine scale changes occurred. However, provisions were made for future automatic selection of plotting arms and boards under the control of the computer.

Mark II system in production

The IP system we have described is interim equipment. All the hardware was put together in less than six months. It was adapted from the Azusa tracking system, previously installed for trajectory measurements. The ultimate goal is automatic impact prediction and range safety action—when the prediction indicates unsafe conditions, the computer would trigger the missile destruct system or fuel cutoff device.

A Mark II Azusa system is in production at Astro-nautics. It will provide trajectory data with substantially lower RMS noise and no bias errors. Extended baselines and the adaptation of correlation detection techniques will further improve the data and extend the maximum tracking range.—End

Table III: Impact Dispersion vs Data Bias (5000 miles impact range)

SF₆ waveguide dielectric breakdown curves

MICROWAVE TUBES have advanced to the point where they can generate more power than transmission lines can handle. One way of getting around this deficiency is to use pressurized dry air inside the waveguide. The power handling capabilities of the line increase roughly with the square of the pressure. Substantial power increases thus call for substantial pressure increases and lead to many mechanical problems.

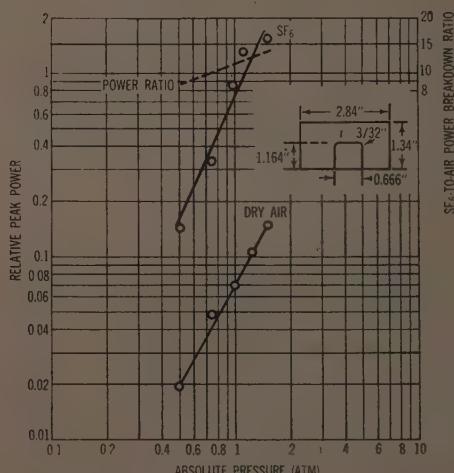
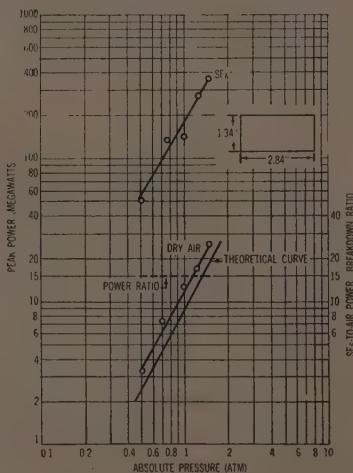
A better method appears to be the use of a gaseous dielectric that would stand the electric stress applied at atmospheric pressure. Several such gases are known and have been applied in high voltage generators and transformers. Sulphur hexafluoride (SF₆) is the most widely used. It has excellent characteristics for a transmission line dielectric: high dielectric strength,

stable properties, extremely low reactive characteristics, chemical inertness, ability to extinguish arcs in a fraction of the time required by air. Under normal (non-arcing) operating conditions, it is also highly inert from a biological point of view. Finally it has a wider range of operating temperatures than other gases of similar dielectric strength, and it doesn't leave carbon tracks on insulating surfaces after breakdown.

With a view to potential usefulness in high power radar applications, USAF's Rome (N. Y.) Air Development Center (RADC) gave Airborne Instruments Laboratory, Mineola, N. Y., a contract to study the use of SF₆ as a microwave dielectric. AIL completed the contract in January 1958. Here are some of its findings:

RG-49U WAVEGUIDE (plane-to-plane configuration, left)—frequency, 2773 mc; cavity loaded Q, 159.5; PRF, 225 pps; pulse length, two microseconds. Single-Ridge-to-Plane S-Band Configuration (right)—frequency, 2812 mc; cavity loaded Q, 165; PRF, 225 pps; pulse length,

two microseconds; cross-section drawing not to scale. Diffusion and ion-pair recombination have decisive effect on breakdown phenomena. Both depend on electrode configuration and spacing. Pressure and ionic nature of gas under test also affect results.



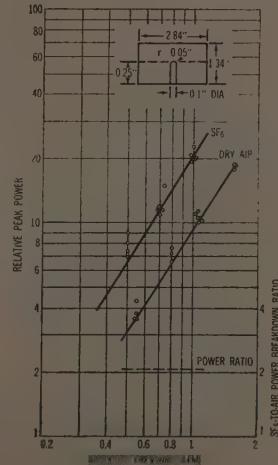
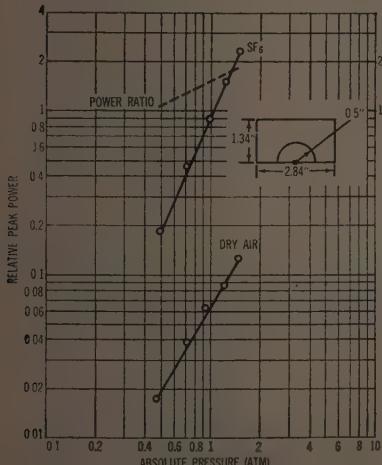
• **Toxicological Aspects**—If electric arcs are generated in an SF₆ atmosphere, several poisonous and corrosive products are formed. These are potentially dangerous, but their effects may be minimized by certain precautions.

• **Waveguide Breakdown at S- and L-Bands**—Gaseous ion concentrations in the dc case vary in a non-linear fashion in the vicinity of an electrode and depend on electrode geometry, spacing, and polarity. At microwave frequencies, diffusion and ion-pair recombination become deciding factors in breakdown phenomena. Both depend on electrode configuration and spacing. In addition, pressure and the ionic nature of the gas under test also affect the results. Hence it is important that microwave breakdown ratios be measured in geometries similar to those actually met in functional equipment.

The greatest microwave powers available at RADC were not enough to break down the SF₆ in most test configurations. Most of the tests were made with the particular test configuration placed at the point of maximum field intensity inside a two-port resonant cavity with a loaded Q of about 150.

Breakdown measurements were made for pressures from 0.5 to 1.5 atm at S-band and one to 1.5 atm at L-band. Each breakdown point was measured at least five times, and the breakdown products were flushed out between readings. Minimum measured breakdown ratio (see Table) is the ratio of peak power required to break down the SF₆ to the peak power required to break down dry air at the same pressure.—End

HEMISPHERE-to-Plane S-Band Configuration (left)—frequency, 2757 mc; cavity loaded Q, 131; PRF, 225 pps; pulse length, two microseconds; cross-section drawing not to scale. **Center: Rounded-Point-to-Plane S-Band Configuration**—frequency, 2752 mc; PRF, 225 pps; pulse

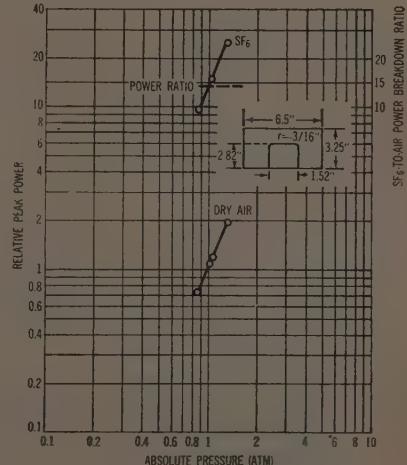


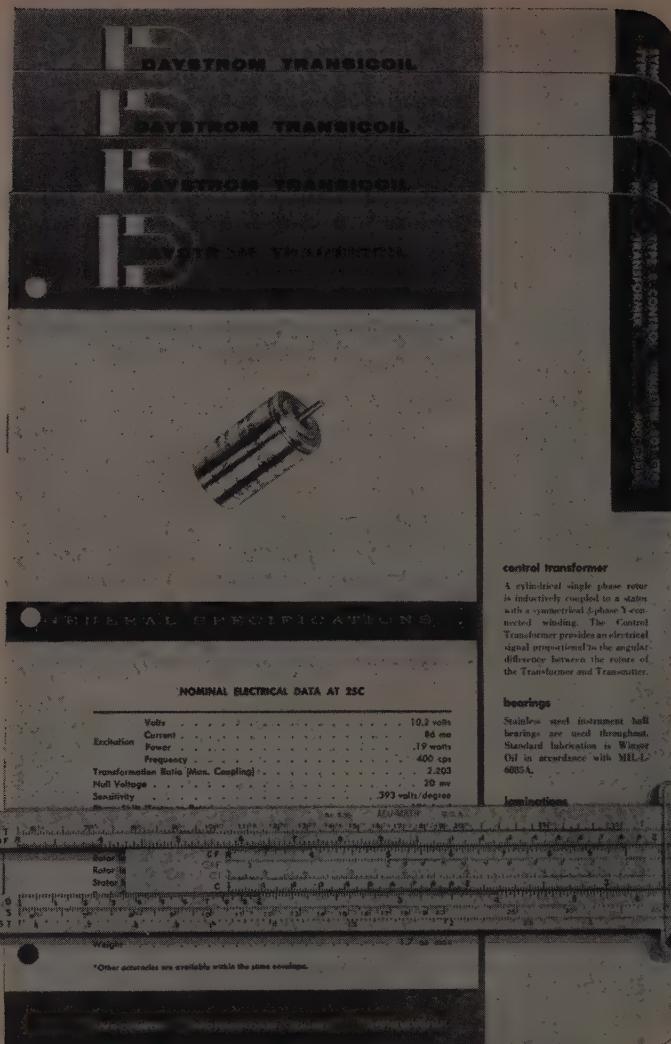
Minimum Power Breakdown Ratios for Various Waveguide Configurations

Band & Waveguide Size	Configuration	Minimum Power Breakdown Ratio (0.5-1.5 atm)	Power Breakdown Ratio for 1 atm
S-band: 2800 ± 45 mc RG-48/U waveguide (1.34 by 2.84 in. ID)	plane-to-plane (full-size waveguide)	15.5	15.5
	single-ridge-to-plane	8.0	10.0
	hemisphere-to-plane	11.0	14.0
	rounded-point-to-plane	2.2*	2.2*
L-band: 1317 mc RG-69/U waveguide (3.25 by 6.5 in. ID)	single-ridge-to-plane	13.6	13.6

*Data scatter was excessive. It should be reduced if further measurements are made. However, this power ratio is certainly less than 5. The radius of the point was 0.050 in.

length, two microseconds; cross-section drawing not to scale. Right: Single-Ridge-to-Plane L-Band Configuration—frequency, 1316.5 mc; cavity loaded Q, 222; PRF, 360 pps; pulse length, six microseconds; cross-section drawing not to scale.





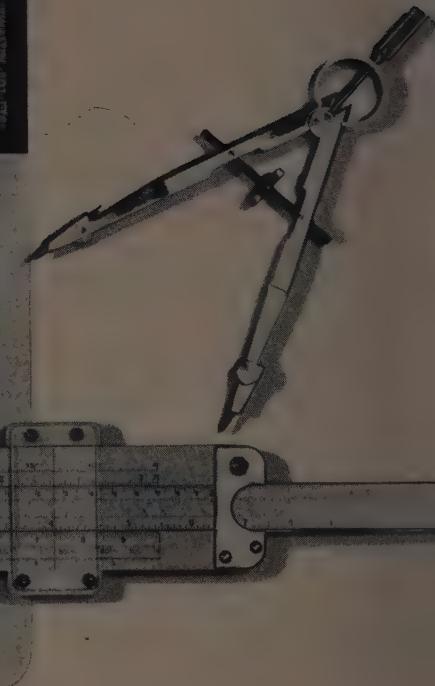
control transformer

A cylindrical single phase rotor is inductively coupled to a stator with a symmetrical 5-phase Y-connected winding. The Control Transformer provides an electrical signal proportional to the angular difference between the rotor of the Transformer and Transmitter.

bearings

Stainless steel instrument ball bearings are used throughout. Standard lubrication is Winter Oil in accordance with MIL-L-6005A.

dimensions



size 8 synchro data

Synchro data for the asking! Daystrom Transicoil has prepared comprehensive data sheets on its popular Size 8 Synchro Line. All the synchro information you need is clearly presented . . . with photos, detailed drawings, electrical characteristics, mechanical specifications, and electrical diagrams.

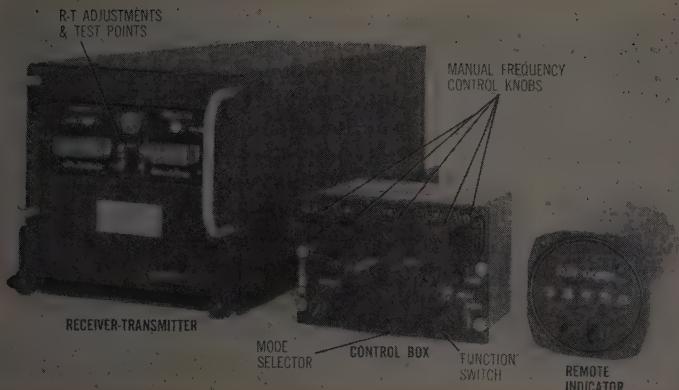
Data Sheets cover transmitters, control transformers, differentials, repeaters, resolvers, and inductive potentiometers. All units are corrosion resistant construction throughout. Accuracies to $\pm 5'$ are available on special order. Write for your free set of Size 8 Data Sheets. Technical information on our Size 11 line is also available. Daystrom Transicoil, Division of Daystrom, Inc., Worcester, Montgomery County, Pa. Phone JUNO 4-2421. In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 19, Ont. Foreign: Daystrom International Div., 100 Empire St., Newark 12, N. J.



DAYSTROM TRANSICOIL

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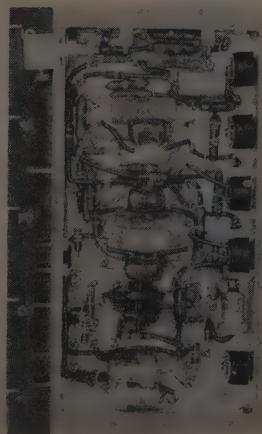


MAJOR COMPONENTS of ARC-62 are receiver-transmitter, control box, and remote indicator. R-T unit is made up of several modules that plug into combined plenum-chassis. Remotely controlled, it may be mounted at any convenient point in the plane. Control box: Operating modes are Manual, Preset, and Guard. Manual control knobs select any one of 3500 frequencies. In Preset, any one of 20 preset channel frequencies may be selected. Function switch shows if set is off, operates main R-T only, or transmitter and both receivers, or switches set to ADF. Remote indicator (right) displays frequency (in mc) on Manual, channel number on Preset, and "GUARD" in that mode.

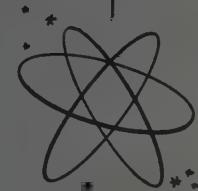


R-T UNIT (top view, cover off)—Circuit functions are in standard modules mounted on base plenum. With no mechanical interconnections between modules (a UDC goal) substitution is easy in line servicing and patch-cable maintenance at depots. Plenum carries forced cooling air from plane's system. Installing unit in rack engages main electric and cooling connectors.

DENSE PACKAGING shows in transistorized second IF amplifier subchassis. Two of these are in R-T unit—one in Main and another in Guard receiver. Mounting technique allows tighter packing of components than printed board and insures stability through better grounding and shielding. Unit has 100-db gain.



design digest



by **Bernard Kovit**

Associate Electronics Editor

ARC-62 forecasts Mach 3+ aero electronics

NOW REACHING prototype stage, the AN/ARC-62 UHF communications set has a double significance: (1) with it, a UHF command set for the aircraft of the '60s is at hand, and (2) it promises adoption of the USAF-industry concept of "uniform design criteria" (UDC) calling for standardized modules that can be readily regrouped for varying form factors with minimum time and cost. RCA's Defense Electronic Products, Camden, N. J., designed the set to WADC Comm & Nav Labs' Exhibits WCLN 58-12 and 58-18, covering modules and UDC, respectively. The ARC-62 boasts 3500-channel capacity, twice that of present UHF comm sets. Power output is upped to 30 W, which, coupled with a reported 2.5-uv sensitivity, improves the S/N ratio by 9 db for normal set-to-set communications. Frequency range is 225-399.5 mc, with 50-kc channel spacing. Set has already been programmed into such varied weapon systems as the F-108 and the B-70 with virtually no redesign.

more on next page

design digest



- MODULES COMMON TO ALL APPLICATIONS
- MODULE TO MEET SPECIALIZED REQUIREMENTS
- MODIFIED MODULE

	RF R-F FRONT END	1st INJECTION	1st IF	2nd INJECTION	2nd IF & DETECTOR	GUARD RECEIVER	POWER SUPPLY	FSK MODULATOR	SINGLE CHANNEL XMTR	250W POWER AMP
UHF TRANSLATOR	●	●	●	●	○					
BASIC VOICE	●	●	●	●	○					
AN/ARC-62	●	●	●	●	○	○	○			
COMMAND VOICE WITH BACKUP R-T CHANNEL	●	●	●	●	○	○	○	○		
ONE-WAY DATA LINK		●	●	●	○		○			
TWO-WAY DATA LINK		●	●	●	○					
FSK EXCITER		●	●	●	●	○				
250-W TRANSCEIVER		●	●	●	●	○				

TRANSLATOR—Table (left) shows ARC-62's basic modules fit several discrete airborne

communications uses. Right and below: Comparison with present ARC-34 comm set.

AN/ARC-34

AN/ARC-62

SIZE COMPARISON (TOP VIEW)

ARC-62 UNIT DIMENSIONS

Unit	Size (in.)			Volume (cu ft)	Weight (lb)	
	H	W	L		ARC-62	ARC-34
R-T Unit	6.5	7.5	16.5	0.47	34	50.5
Control Box	3.75	5.75*	3.75	0.047	2.9	2.7
Mount					**	3.6
Remote Indicator (optional)	3.125	dia*	6.5	(0.037)	(2.2)	not provided
Total (not including remote indicator)				0.554	36.9	56.8

* Standard control panel size.

** Required only in special cases.

DESIGN & PERFORMANCE SPECS

Frequency range: 225-399.95 mc

Available channels: 3500

Channel spacing: 50 kc

Channel change time: 4 sec (max)

No. of Preset channels: 20

Squelch: peak-to-average type, simplified setting

Pressurization: R-F module only (built in)

Power source: three phase, 400 cps

Power drain: 260 W for 33 per cent transmit-receive duty cycle (including 25 W min power radiated by antenna)

Receiver sensitivity: 3 uv or better over entire tuning range for 10-db (S+N)/N ratio

Audio output: 0.1 W into 150-ohm load

Receiver frequency accuracy: center frequency is within ± 6 kc of nominal channel frequency

Selectivity: 44-kc bandwidth at 6 db down, 110-kc bandwidth at 60 db down

Input impedance: 50 ohms, nominal

Power output: 25 W (min) into 50-ohm load

Xmtr frequency accuracy: within ± 5 kc of nominal channel frequency

Frequency modulation: less than 1-kc peak deviation when using AM

Sidetone distortion: 15 per cent or less, with any audio frequency from 300 to 4000 cps and input adjusted to 1.4V

Carrier distortion: under 10 per cent with any input between 300 and 6000 cps and adjusted to get 90 per cent negative modulation with no audio peak clipping

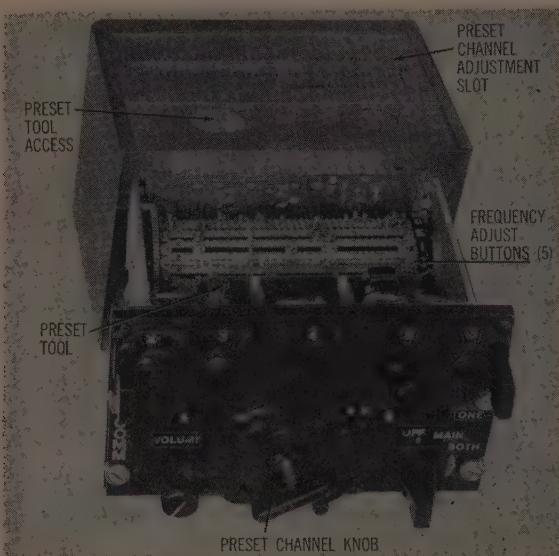
Spurious frequency response: 80 db minimum, except image, 60 db

Altitude: 80,000 ft and higher

Mean time between failures: 500-750 hr

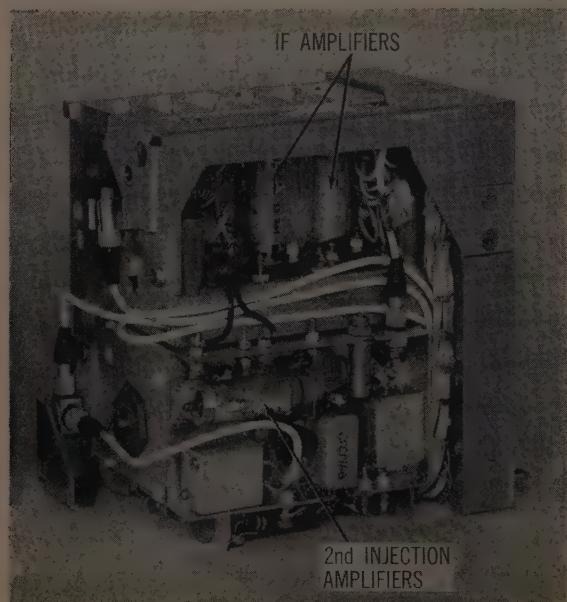
Temperature: -55 to +95 deg C

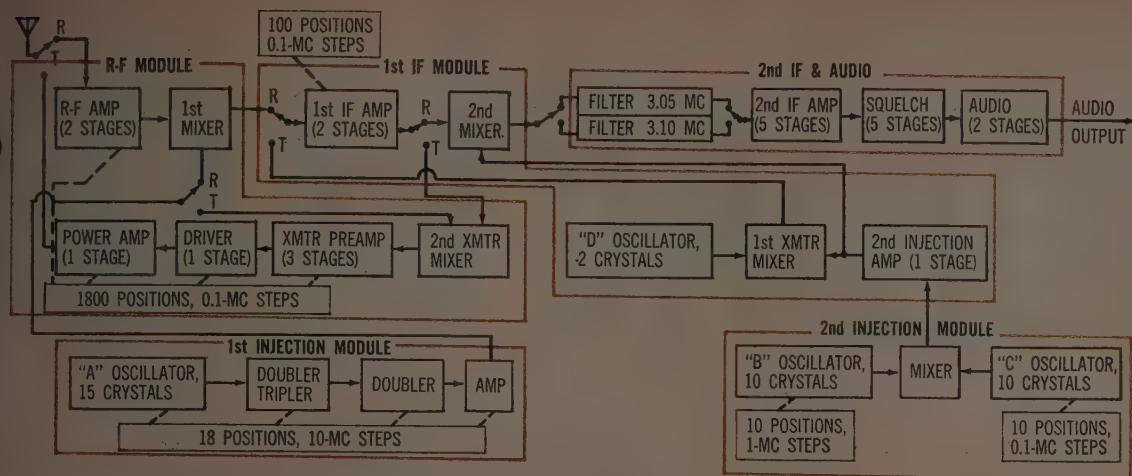
Shock: impact, 15 G; crash, 30 G



CONTROL BOX DESIGN—Channel-preset drum has five-digit capacity—one digit more than ARC-34. Frequency adjustment is made to scale positions on edge of access slot in dust cover.

FIRST IF module with cable connectors to ease testing.



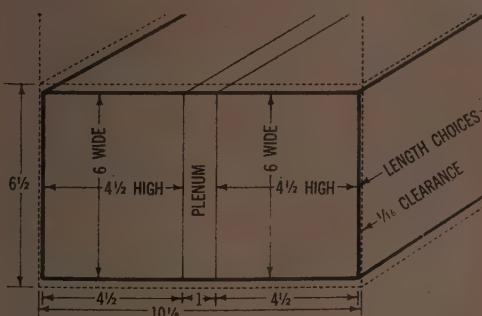
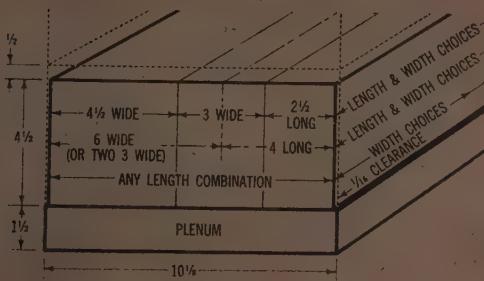


RECEIVER-TRANSMITTER—Overall block diagram (above) shows ARC-62's operational design. Note especially the dualed crystals (first IF) and filters (second IF), added to double the set's channel capacity, and the use of separate electromechanical positioning elements in individual modules rather than a centralized mass of gears and drives. Functional breakdown of receiver-transmitter modules:

- RF module contains main receiver RF tuning and mixing circuits, transmitter preamp, power amp, and modulator circuits. It also holds two transmitter power supplies (300 and 600 V)—the only HV needed in the

set. By pressurizing this module, which has its own channel-tuning elements and an axial-flow blower, RCA was able to avoid pressurization of the entire set.

- First injection module provides a signal, adjusted in 10-mc steps, for synthesizing the receiver's first injection signal and the transmitter antenna carrier.
- First IF module (bottom left, opposite page) produces variable IF that tunes to 100 separate frequencies, ranging from 30 to 39.9 mc, with 100-ke spacing. Second injection amp portion is geared to variable IF and covers 33.05-42.95 mc.
- Second IF and audio module provides main receiver 2nd IF selectivity, amplification, AGC, squelch, and ADF signal output plus sidetone, volume control, and audio output for both receivers.
- Second injection module provides frequencies ranging from 33.05 to 42.95 mc in 0.1-mc steps. Crystal-controlled oscillators produce a difference beat in first IF's second mixer.
- Guard receiver module (below is a separate, fixed-tuned receiver that gives the same performance as the main receiver, with which it shares only the audio amplifier. Hycon crystal filter, used for both injection voltages, gives stability over a wide range of ambient temperatures. Module's volume is 40.5 cu. in.



UNIFORM Design Criteria apply to case and module. For case: height, 6.5 in.; width, 4.875, 7.5, or 10.125 in. (approval can be gotten for 2.250, 3.563, or 15.375 in.); length may vary, but 10, 16, or 18 in. max is preferred. For modules: H, 4.5 in.; W may be 3, 4.5, 6, or 9 in. (last two preferred); L, 1.5-10 in. max in $\frac{1}{2}$ -in. increments. Manufacturer should use UDC as design guide; some variations are expected and provided for.



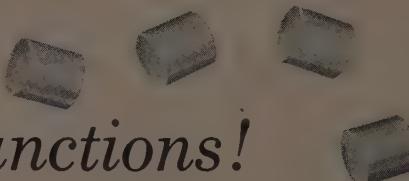
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Holding a "zone" at a constant temperature...despite wide variations in ambient...often demands heating or cooling systems that are complex. Usually a compromise is employed, resulting in controlling temperature at a point *above* ambient. To hold temperature *below* ambient requires refrigerants, ice packs, or forced liquid cooling. These techniques have inherent limitations.

Now, RCA announces developmental Thermoelectric Elements...unique and extremely compact devices capable of producing "boiling heat" or "freezing cold" in small "zones". Circuitry is simple. You have infinite control from maximum cooling to maximum heating through variations of the dc power supplied to one device. With no moving parts, vibration is eliminated—long life assured.

RCA Thermoelectric Junctions are excellent for service in laboratory "ovens" or "cold chambers". The new elements make practicable, for the first time, the manufacture of simple and completely transportable temperature-control apparatus capable of holding temperatures constant *below* ambient.

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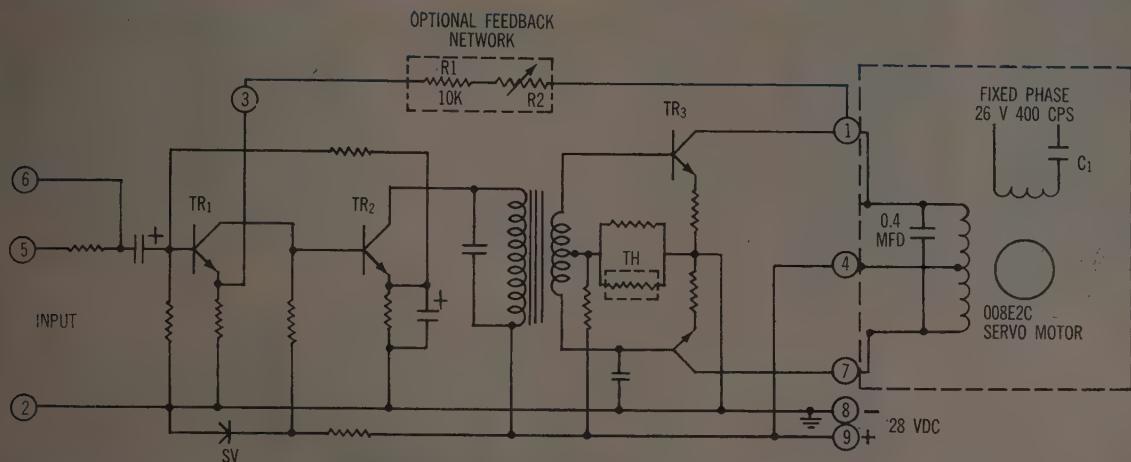
For information on developmental samples, please contact the RCA sales office nearest you, or, write direct to RCA Commercial Eng., Section E-59-NN, Somerville, N. J.



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Semiconductor & Materials Division

Somerville, N. J.



CIRCUIT consists of two cascaded high-gain transistors feeding a push-pull power output stage. Emitters of the power transistors are returned to ground via a thermistor (TH) for temperature stability. The 008E2C is driven directly from the amplifier. (Another, slightly longer

version of the amplifier includes an output transformer to supply two watts at 26 V). In the external circuit, C_1 is adjusted for maximum torque at stall; R_1 and R_2 adjust the gain of the amplifier over a range of two-to-one.

Ketay Subminiature Servo Amp Characteristics

Voltage Gain	200-1000 nominal
Input Impedance	500 ohms min
Max Input Voltage	-5 V
Frequency	380-420 cps
Power Source	28 V dc 95 ma max
Output	
Type	direct push-pull
Volts	40 V RMS
Power	2 W continuous
Load Impedance	812 ohms
Typical Load	size 08 servo motor
Weight	1 oz
Operating Ambient	-55 to +100 deg C (no heat sink required)
Connector	9-pin miniature (solder turret)
Package	hermetically sealed with mounting studs
Volume	0.8 cu in.

One-ounce servo amp puts out two watts

ONE of the latest miniaturized servos is a one-ounce, 0.8-cu in. amplifier that can deliver two watts continuously into a 40-V, center-tapped servo motor. The amplifier will operate efficiently in ambients from -55 to +100 deg C without a heat sink. Developed by Ketay Dept., Norden Div., United Aircraft Corp., Commack, N. Y., the new amplifier replaces units that are several times larger and require heat sinks.

To pack so much power into so small a space called for "unique

construction and packaging technique providing an 86 per cent space factor," according to Gus Saunders, amplifier project engineer at Ketay. Components are sandwiched in between two 1/16-in.-thick printed circuit boards. The two boards with their components (standard resistors, capacitors, and four silicon transistors) are wired to the header and placed in the amplifier case, sealed, and vacuum-impregnated. Provision is made to adjust the gain from 200 to 1000

more on next page

with an external resistor (see *Schematic*).

The applications of the amplifier are in aircraft and missile servo systems. Write in No. 53 on Reader Service Card for more data.—JH

SUBMINIATURE servoamp has components sandwiched between two printed circuit boards.



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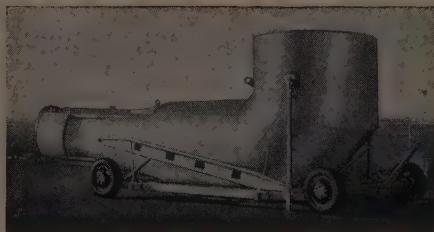
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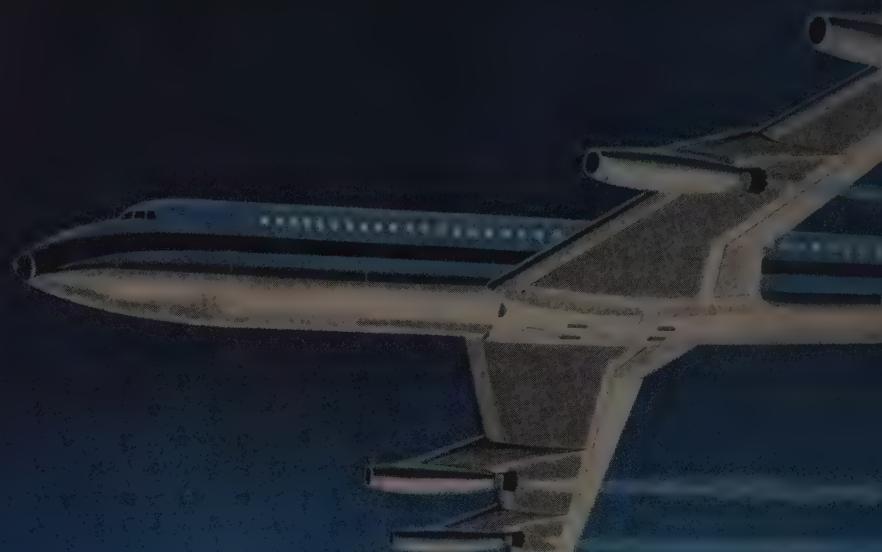
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Moog servoactuators are compact, lightweight package units that typically include an actuating cylinder, servovalve, and feedback sensing device. These integrated units offer the advantages of a comprehensive custom design including reduced complexity and retaining high performance. Additional special features can be incorporated to meet particular applications.

In addition to ICBM and other missile, rocket, and aircraft applications, Moog servoactuators can function wherever rapid, accurate, high force positioning is essential in an electro-hydraulic system.

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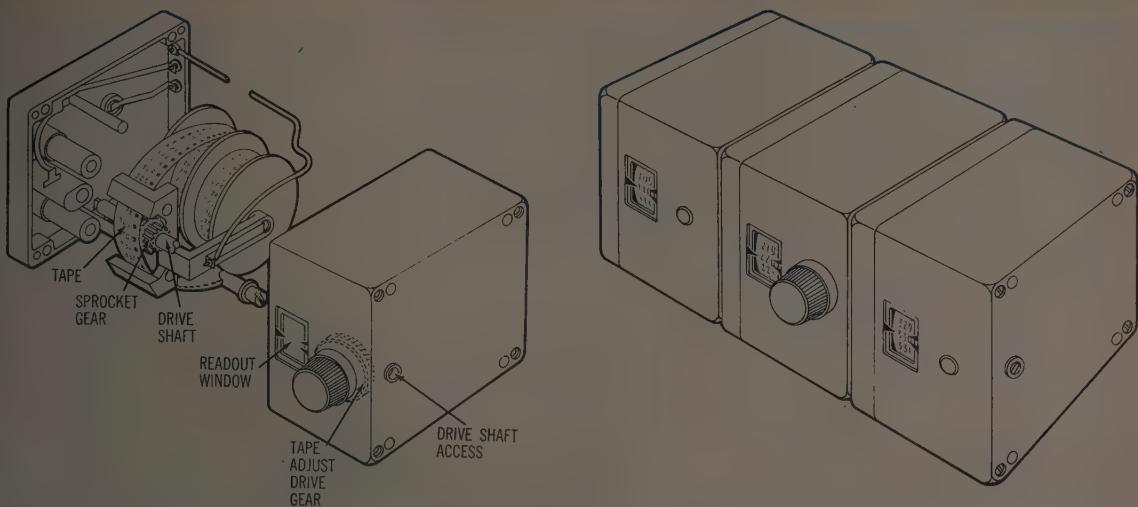


FIGURE 1: Internal view (left) of B & H Instruments Ta'Pot H5600 direct tape readout device. Bottom ganged

units allow single-knob adjustment of related functions. Single-case dimensions are $2 \times 2\frac{1}{2} \times 2\frac{3}{4}$ in.

Slidewire-tape pot boasts "infinite" resolution

Twenty years went by without a new patent in potentiometers—until the slidewire-tape pot came along. Earlier, test engineers had to string a resistance wire wall-to-wall to get anything near lab accuracy. With the instruments formed up around the slidewire tape, you can now get a calibrated accuracy of 0.1 per cent in digital readout of linear or non-linear pressure and temperature measurements.

A PRECISION tape potentiometer whose slidewire-tape element is calibrated and marked for direct digital readout has been adapted to a variety of R&D and field test equipment B & H Instrument Co., 3479 W. Vickery Blvd., Ft. Worth 7, Texas, has designed several pieces of automatic test equipment

around the tape potentiometer for such applications as jet engine field analysis. The slidewire has actually been used in B & H's Jetcal test sets as a manually operated indicator for a number of years.

The tape potentiometer is basically a resistance wire bonded with in one edge of a laminated Mylar

tape (Fig. 4). The wire may be either straight or helical, depending on the amount of resistance you need.

An automatic calibration technique is used to scale the tape for the particular application. This involves comparing the tape under test with a precise 60-ft master tape. Digital values, as required by the pot's application, are automatically printed along the face of the tape. (Up to 100 calibration points can be made per foot of slideware.)

In calibration, the tape may be perforated with sprocket holes, so that it can be engaged by a positioning and driving device. Exceptionally accurate non-linear calibration for thermocouples, thermistors, and flow transducers is achieved without slidewire tapping. Con-

more on next page

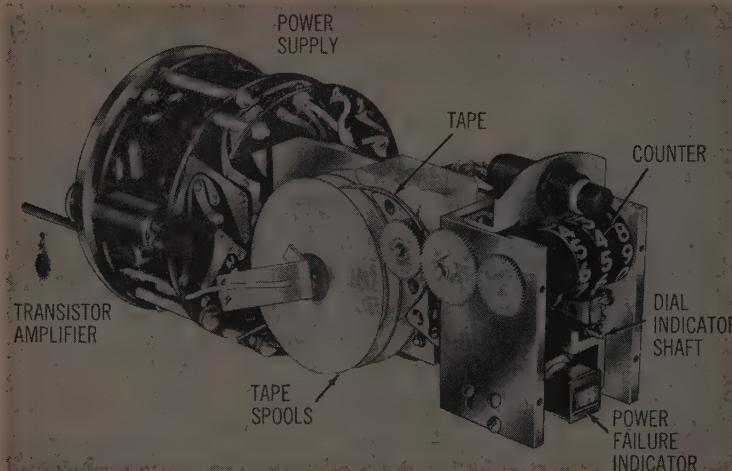


FIGURE 2: Combined digital and dial temperature indicator (B-1105 Auto-Temp). Internal atmosphere of hermetically sealed unit is nitrogen. Unit is three inches in diameter and seven inches long.

trolled by coded signals built into the master tape, the printing or hole spacing is varied to conform to the desired ratio between digital indication and slidewire resistance.

With this technique, the tape calibration is made accurate to about 0.1 per cent for either linear or non-linear functions. This characteristic has been obtained by B & H Instrument in a miniature analog-to-digital millivoltmeter indicator, for instance. The linearity of this instrument is pegged at 0.05 per cent, and resolution is infinite.

Direct digital readings in any units

When the slidewire-tape potentiometer is used with transducers having strain gages as measuring elements, you have a system that will give direct digital readings of weight, pressure, force, etc., in any units desired. Its 0.1 per cent accuracy matches that of the transducer itself. When the pot is used with transducers whose output is resistive (e.g., resistance thermometers or thermistors) direct digital indications of narrow temperature spans are obtained in an operational unit that outstrips many lab equipments.

Two readout arrangements are possible:

- With the calibrated points printed on the tape and viewed through a window on the front panel of the instrument, linear, parabolic, hyperbolic, or logarithmic

functions—in any scale units—may be read.

- With a digital in-line counter geared to the slidewire driveshaft, functions with a variation of 15 per cent in slope can be handled.

Slide-wire furnished in any lengths

Figure 1 shows an example of the first readout arrangement. In this instrument, the slidewire is furnished in 120-in. lengths. Resistance ranges from 100 ohms to 100 K. Thanks to the unit's straight sides and interlocking driveshaft ends, two or more units can be ganged for single-knob setting of related functions without gears or couplings.

Figure 2 shows an example of the dial readout arrangement. In this unit, the slidewire is contained on two spools and is transported between them by a sprocket drive. Calibrated as a pyrometer for use with any type of thermocouple, it operates as shown in Figure 3. Used for measuring turbine inlet temperature or exhaust gas temperature, this device has an accuracy of 0.085 per cent in a range of 500 to 1000 deg C when calibrated for chromel-alumel thermocouples.

For ac bridge applications, the device may be calibrated to correct for droop or any non-linearity. With differential transformers, it can be calibrated to present pressure and flow values with great ac-

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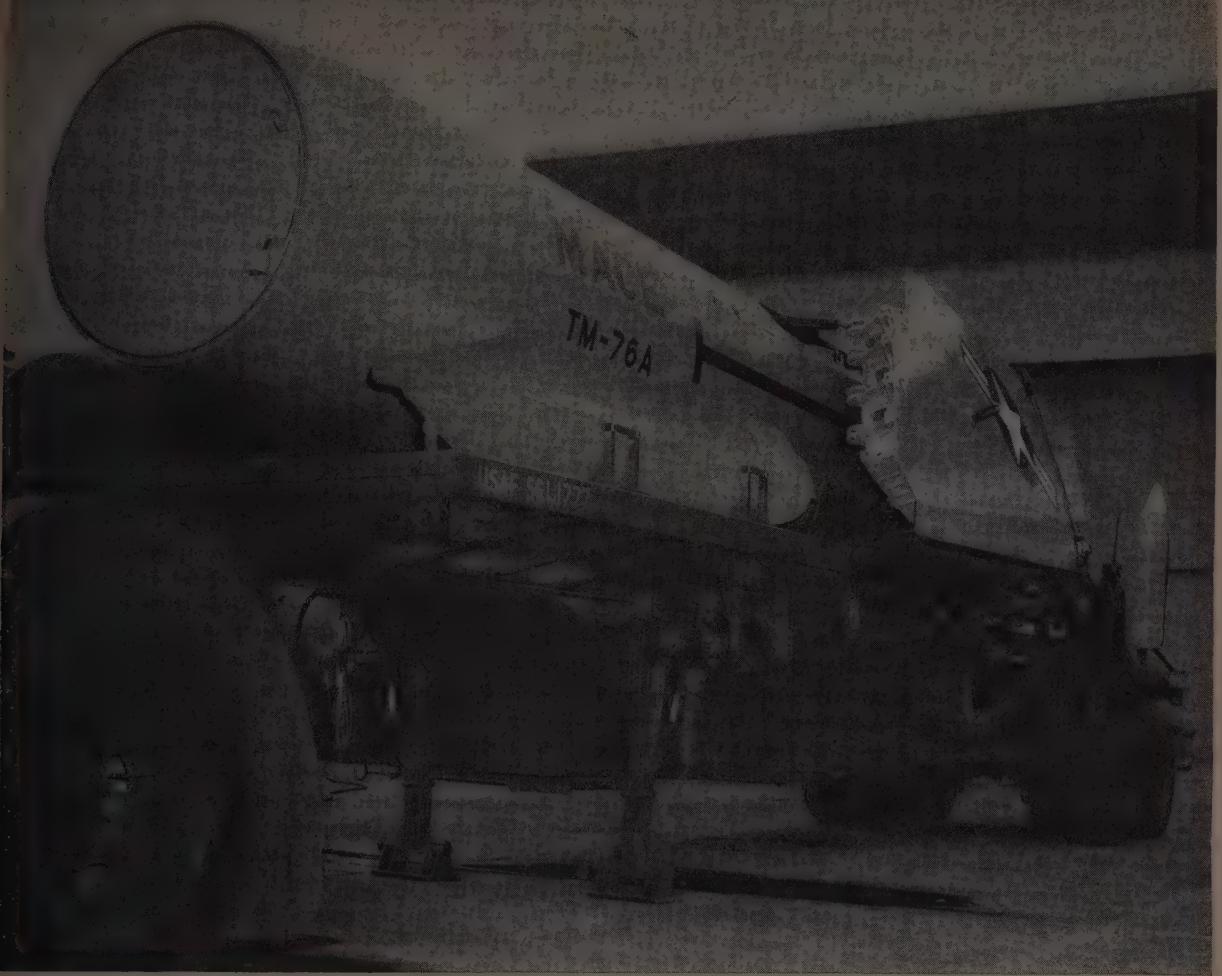
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more on page 152



That's a precision-forged Alcoa Aluminum wing root you see in the near edge of Martin Mace's wing panel. It means the surface-to-surface tactical missile can travel

to launching sites compactly, wings unattached. It means that the wings can be field mounted, ready immediately for full flight performance.

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Each wing panel was designed to extend 11.45 ft from a central wing root. Sweepback and negative dihedral dictate that this root conform to an intricate, twisted, compound curve . . . with tolerances within a

few thousandths at every point in both contour shape and over-all thickness of the root.

Conventional production? Prohibitive. It would require either complex and costly machining on complex and costly machines (plus extensive hand-finishing afterwards), or—even more costly—custom-designed machines built for this job alone.

Working closely with Alcoa engineers, the Martin people found the answers. By precision-forging Alcoa® Alloy 7075-T6 in two pieces, each with a flat back, contour tolerances within 0.005 in./in. are attained by forging alone. And with such accuracy of contour, accuracy of thickness of the assembled two-piece root

is attained simply by slab-milling the mating surfaces!

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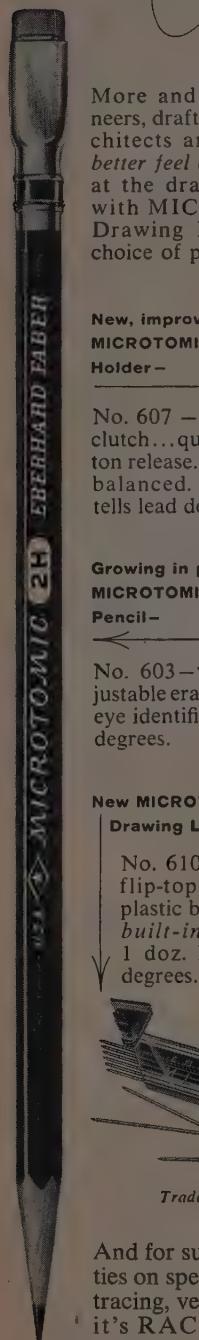
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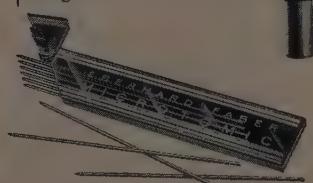
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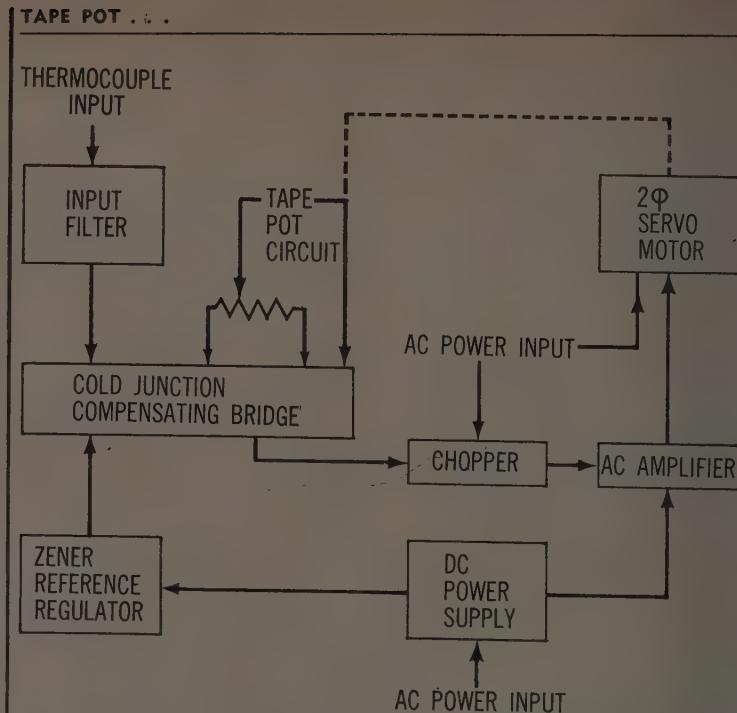


FIGURE 3: Temperature-measuring configuration. Instrument will follow temperature changes at 350 deg/sec, says B & H. Temperature range is -55 to +71 deg C.



Playback on performance

Autonetics' NADAR increases flight training efficiency by making a magnetic-tape recording of everything an airplane's fire control system puts on the radar scope. Minutes after pilot lands, complete record of his performance can be viewed on oscilloscope of NADAR console. Compact, lightweight, airborne tape-recorder (shown above in officer's hand) is fully automatic, has two-hour recording capacity. NADAR is invaluable for pilot and aircrew evaluation and flight testing... and remember, military pilots are always training. Write for literature.

Autonetics

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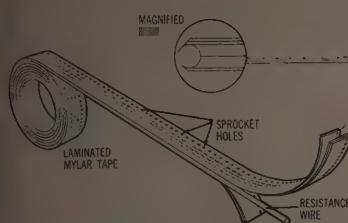


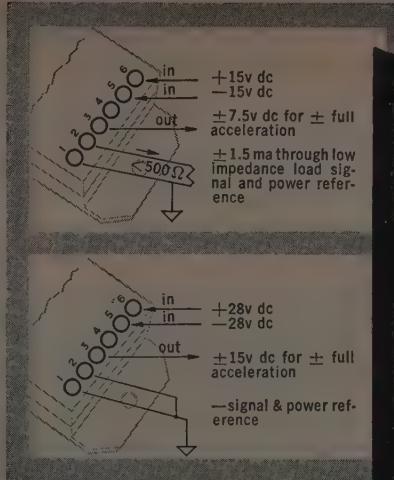
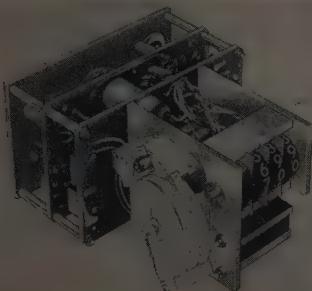
FIGURE 4: Wire is embedded in edge of laminated tape by a bonding process. Tape lengths of 120 and 144 in. are used, depending on the desired range of test measurements. By varying the distance between centers of adjacent holes by a few thousandths of an inch, you set up a non-linear resistance-to-hold-count relation.

curacy. Operating on 115 V, 60- or 400-cps power, the device needs only 20 va.

Basically, the slidewire tape pot design gives you a very accurate analog-to-digital converter for both linear and non-linear inputs. Hence B & H has included binary and decimal contact-making counters to set up a signal source for punched and magnetic tapes and computers and for programming and controlling purposes.

Adding a re-transmitting slide-wire gives a signal source for recorders, telemetering, and analog computers. With a pulsed or sine wave input, the unit can be used as a tachometer or frequency meter, with a range of zero to 800 cps. Write in No. 56 on Reader Service Card for more data.—BK

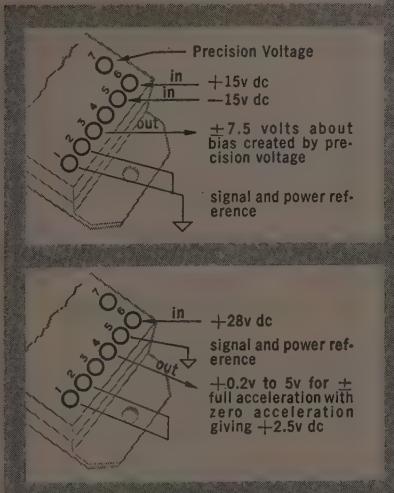
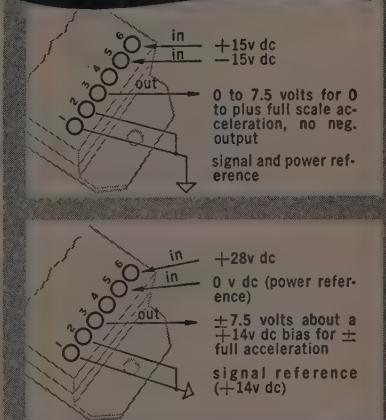
ANOTHER package version of the potentiometric temperature indication (AutoTemp), set up to read in degrees Centigrade.



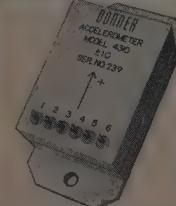
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Split case version of the Model 4310 for use in limited space applications; electronics on right, sensing unit on left.

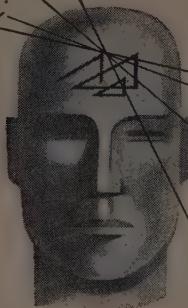
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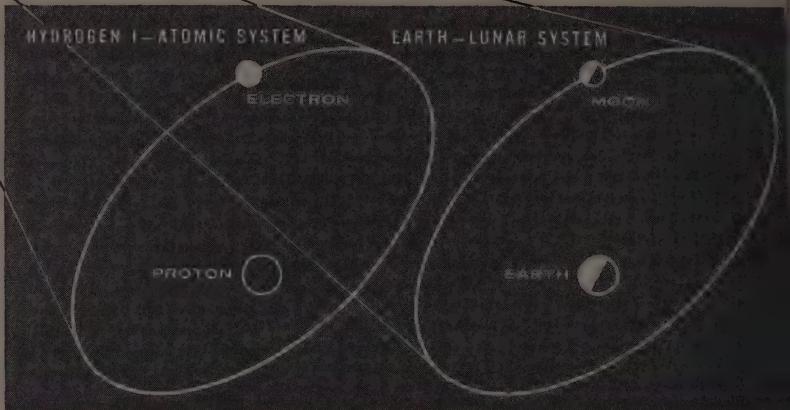
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BOLD MINDS



THROUGHOUT HISTORY.....

BOLD MINDS have sought to understand the forces at work in the universe, and as they developed working hypotheses, endeavored to turn all knowledge to their own purposes, devising philosophical and mechanical systems of their own.

As old hypotheses become inadequate or untenable, thinking men devise new ones. So the concept

of a "flat" world has changed to an oblate orbiting spheroid—mere speck in a vast and expanding universe; so "empty" formless space is regarded as a curved continuum occupied by random knots of turbulence (creating the new branch of mechanics—hydromagnetics).

Today new horizons of discovery and surmise arise before the speculative mind.

ENGINEERS AND SCIENTISTS AT REPUBLIC FEEL KINSHIP WITH ALL BOLD MINDS OF PAST AND PRESENT, AS THEY FACE THE EXHILARATING CHALLENGES OF CREATING VEHICLES TO FLY IN ENVIRONMENTS WHERE NEW APPROACHES IN THERMO/AERODYNAMICS MUST BE MADE...AS WELL AS APPROPRIATE PROPULSION AND ELECTRONIC SYSTEMS TO POWER AND GUIDE TRANSIT IN SPACE

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- High Altitude Atmosphere Physics
- Re-entry Heat Transfer
- Hydromagnetics
- Ground Support Equipment

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- Gaseous Electronics
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- Physical Chemistry
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- Instrumentation
- High Power Pulse Electronics

NUCLEAR PROPULSION & RADIATION PHENOMENA

- Nuclear Weapons Effects
- Radiation Environment in Space
- Nuclear Power & Propulsion Applications
- Nuclear Radiation Laboratories

A new \$14,000,000 Research Center—to be completed this year—is part of Republic's far-ranging R&D programs aimed at major state-of-the-art breakthroughs in every flight regime & environment.



Send resume in complete confidence to:

Mr. George R. Hickman, ENGINEERING EMPLOYMENT MANAGER — DEPT. 6E

REPUBLIC AVIATION

FARMINGDALE, LONG ISLAND, NEW YORK

May 1959
(good until 7/15/59)

Employment Inquiry Form

(NOT an application for employment)

THIS INQUIRY FORM is a service that makes it easier for the interested reader to explore employment opportunities with organizations featuring recruitments advertising in this issue.

To use this Form, follow these simple steps:

- (1) Tear out this page.
- (2) Check off the organization(s) listed below whose employment offers are of interest to you. Use typewriter or pencil.
- (3) Turn to the back page of this Form and answer the questions on it.
- (4) Mail this form (in a stamped envelope) to:

Reader-Service Dept.

SPACE/AERONAUTICS

205 East 42nd St.

New York 17, N.Y.

We will do the rest and promptly forward a copy of your Inquiry Form to each of the organizations you have checked. Depending on their specific personnel requirements, they will get in touch with you at your home.

I am interested in the employment opportunities at:

<input type="checkbox"/> AiResearch Mfg. Co.	278	<input type="checkbox"/> Missiles & Space Div.; United Aircraft Corp.	249
Bendix Aviation Corp.	164	<input type="checkbox"/> North American Aviation	
<input type="checkbox"/> Systems Div.	158	<input type="checkbox"/> Autonetics Div.	157
<input type="checkbox"/> York Div.	198	<input type="checkbox"/> Columbus Div.	162
<input type="checkbox"/> BENDIX-PACIFIC	278	<input type="checkbox"/> Los Angeles Div.	113, 160, 166, 219
<input type="checkbox"/> Garrett Corp.		<input type="checkbox"/> Rocketdyne Div.	164
General Electric Co.	166	<input type="checkbox"/> Pan American Airways, Inc.; Guided Missiles Range Div.	165
<input type="checkbox"/> Flight Propulsion Div.	160	<input type="checkbox"/> R C A	158
<input type="checkbox"/> Heavy Military Electronics Dept.	162	<input type="checkbox"/> Raytheon Mfg. Co.	159
<input type="checkbox"/> Missiles & Space Vehicles Dept.	161	<input type="checkbox"/> Republic Aviation Corp.	154
<input type="checkbox"/> Johns Hopkins University; Applied Physics Lab.	163	<input type="checkbox"/> Solar Aircraft Co.	165
<input type="checkbox"/> Lear, Inc.	102	<input type="checkbox"/> Systems Development Corp.	254, 255
<input type="checkbox"/> Martin Co.; Denver Div.	108, 109	<input type="checkbox"/> United Aircraft Corp.; Missiles & Space Systems Div.	249

OTHER (Some organizations' recruitment advertising in this issue may have arrived too late for inclusion in the above list. If you are interested in the employment offers of any of these organizations, just note its name and the page number of its advertisement in this space. Please refer only to ads keyed to this form.):

NOTE: If you have an immediate interest in any special employment opportunity advertised in this issue and would like to give more details about your qualifications than can be noted on this Form, we advise you to send your resume directly to the person or department given in the advertisement. We'd appreciate it if you'd mention SPACE/AERONAUTICS in your application.

May 1959
(good until 7/15/59)

Employment Inquiry Form

Please type or print (with pencil)

(NOT an application for employment)

FIELDS OF INTEREST (in order of importance, note the general fields in which you would like to work—e.g., basic research, dynamics, structures, rocket propulsion, electronic systems, pneumatics, testing, materials, production, ground support, etc.):

SPECIALIZED JOB EXPERIENCE (describe the specific technical areas in which you have worked—e.g., flutter, fatigue, fuel systems, circuit miniaturization, servo systems, hydraulic pumps, tool engineering, orbit mechanics, telemetry, data processing, wind tunnel testing, etc.):

JOBs AND EDUCATION

List your last 3 employers:

EMPLOYER	CITY & STATE	YEARS EMPLOYED	JOB TITLE OR FUNCTION

List your college and university degrees:

SCHOOL	YEARS ATTENDED	DEGREE

Special Training

PERSONAL DATAAGE U. S. CITIZEN YES NO If not, when do you expect to become a citizen?

Name:

Home Address:

Home Telephone:

Make sure you have checked the companies you are interested in on the other side of this Form. Then put the Form in a stamped envelope and mail it to Space/Aeronautics.

It's great to be proud of the place you work

What makes a successful engineer?

Initiative—experience—imagination—intelligence are all important factors. But there is at least one more—enthusiasm.

Young engineers at Autonetics are *enthusiastic*. They're fired up about the projects they work on, such as the advanced inertial-navigation systems for the Polaris-carrying subs, and the guidance and control system for the Minuteman missile.

Variety sparks their enthusiasm. Autonetics' young men also designed RECOMP II, a general purpose, all-transistor, digital computer; NUMILL, a completely automatic, machine tool control system; BACE, high-speed automatic checkout equipment; and many other industrial and military products.

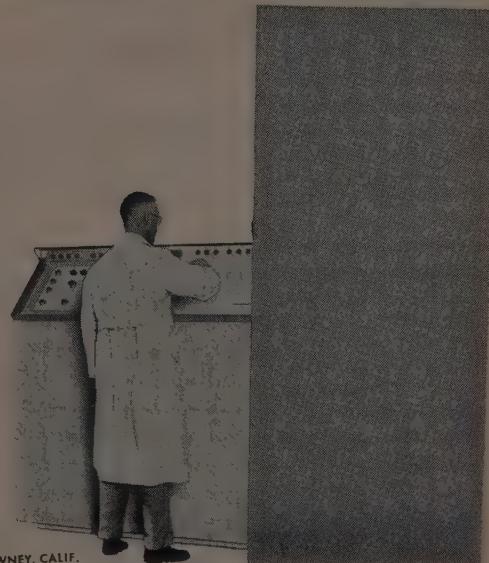
Today at Autonetics there is room for engineers and scientists who seek unusual creative problems in electronics and electromechanics. Please send your resume to Mr. D.E. Benning, 9150 East Imperial Highway, Downey, California.

Autonetics



A DIVISION OF NORTH AMERICAN AVIATION, INC., DOWNEY, CALIF.

INERTIAL NAVIGATION / ARMAMENT CONTROL / FLIGHT CONTROL / COMPUTERS AND DATA PROCESSING



Among the achievements of Autonetics' young men: The first successful airborne all-inertial navigation system...first navigation system accurate enough to guide the USS *Nautilus* and *Skate* on their historic voyages beneath the Arctic ice...first successful automatic star tracking by an inertial navigation system during daylight flight...first inertially stabilized gyro platform proved operable in any kind of maneuver...first successful completely automatic landing system for supersonic missiles and aircraft...first transistorized portable digital computer with "big computer" capabilities.

Check Employment Inquiry Form on Page 155



THIS ENGINEER SUFFERED FROM FOUR-WALL MONOTONY

Even before the day's work began he was *trapped*—by routine assignments, routine schedules, routine methods, and worst of all, by four walls of his never-changing office.

What did he do about it? Made the smartest move possible: he came to RCA Service Company, where engineers are individuals, not adding machines. He found adventure and real "fun" work, as an RCA Field Engineer. At last, he could see a job through—apply his theories and ideas right in the field. He broadened his almost lost horizon with top RCA specialists who are really "hot" in their fields.

You can do the same. If you're an electrical or mechanical engineer suffering from four-wall monotony, cure that syndrome by starting on a real *engineering* career. First step—send your resume today to: Mr. James Bell, Employment Manager, Dept. Y 19-E, RCA Service Company, Cherry Hill, Camden 8, New Jersey.



RCA SERVICE COMPANY

A Division of Radio Corporation of America



ENGINEERS:



The kind of work
you want in
**MISSILE
ELECTRONICS**



The kind of life
you want for
your family

GET *BOTH* AT
BENDIX YORK

**ELECTRONIC
ENGINEERS**

PHYSICISTS

MECHANICAL ENGINEERS

- Challenging opportunities in **CIRCUIT DESIGN, PULSE & VIDEO CIRCUITRY, MICROWAVE, DIGITAL & ANALOG COMPUTERS, SEMI-CONDUCTORS, COMPONENT AND CIRCUIT RELIABILITY.**

- Interesting work on **FUZING TECHNIQUES, BEACONS, SIMULATORS, SPECIAL TEST EQUIPMENT.**

- Bendix York offers you the opportunity for rapid professional growth and advancement. Enjoy the small-company atmosphere of an expanding division of one of America's largest engineering and manufacturing corporations . . . And the way of life in and around York, Pennsylvania is ideal for the entire family. It combines the charm and grace of rural living with the many advantages of a dynamic and progressive community.

Let us hear from you!
Address replies to: Dept. S
PROFESSIONAL EMPLOYMENT

Bendix

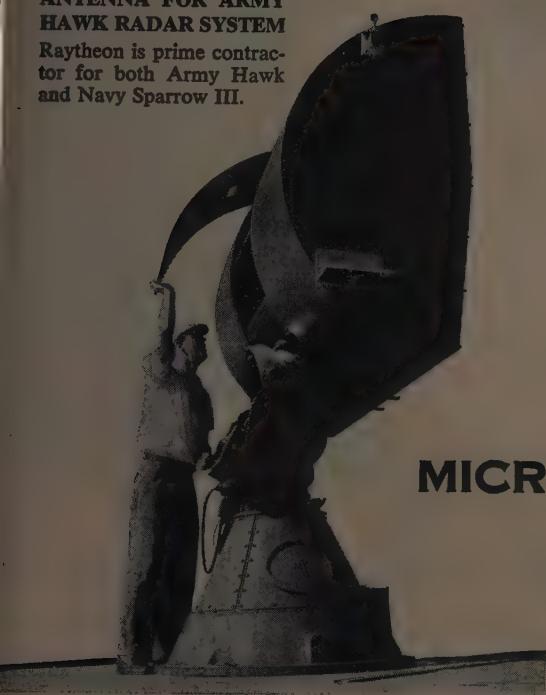
AVIATION CORPORATION

York Division

York, Pennsylvania

"The way of work for you,
the way of life for your family!"

**ANTENNA FOR ARMY
HAWK RADAR SYSTEM**
Raytheon is prime contractor for both Army Hawk and Navy Sparrow III.



MICROWAVE ENGINEERS

ANTENNA • RF COMPONENTS

**...FOR RAYTHEON'S LONG-RANGE PROGRAM
OF ADVANCED MISSILE DEVELOPMENT**

Engineers and physical scientists interested in professional association with a *future* in the challenging areas of microwave development and design should consider Raytheon's advantages.

Senior and intermediate engineers with BS or advanced degrees and appropriate experience are needed for microwave equipment and component development and design of the most advanced types.

- Antenna (ground, airborne and missile application).
- RF Components (strip-line, broadbanding techniques; high-power components, filters, rotary joints, mixers).

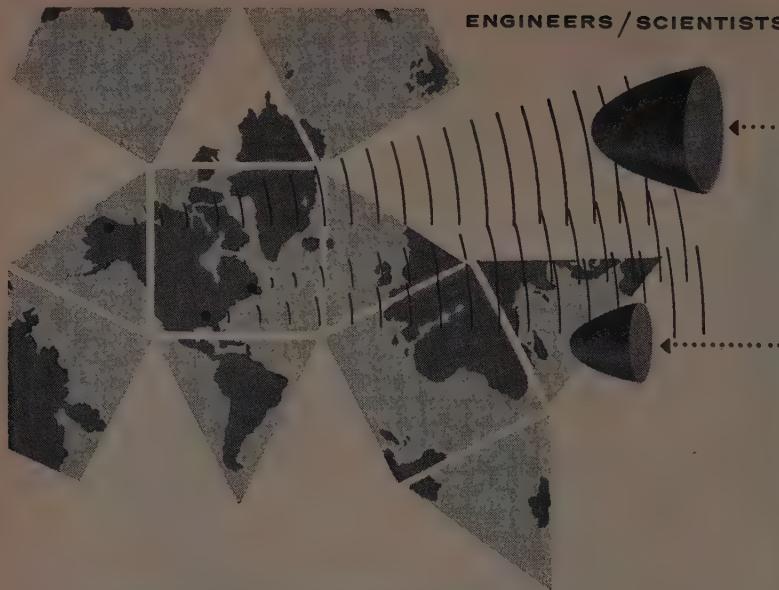
You and your family will enjoy the advantages of living in the Boston metropolitan area. Modern benefits.

Please send complete resume to William F. O'Melia, Raytheon Manufacturing Company, Missile Systems Division, Bedford, Massachusetts.



Excellence in Electronics

ENGINEERS / SCIENTISTS



GENERAL ELECTRIC'S OBJECTIVE:
CREATE NEW LONG-RANGE
RADAR SYSTEMS TO REPLACE
BRUTE FORCE DETECTION METHODS

The Missile Detection Systems Section invites engineers with high creative and analytical abilities to join —

SYSTEMS DEVELOPMENT GROUP, which initiates and formulates basic systems concepts related to extremely long-range radar. Optimize the relationship between operational requirements and the most recent developments in the electronic art.

SYSTEMS EQUIPMENT GROUP, which converts generalizations established by Systems men into detailed components that comprise engineering specifications of the systems. Issue purchase specifications; conduct liaison.

At least 4 years' related experience required in one or more of these areas: Radar Systems Engineering; Electronic Countermeasures Systems Engineering; D&D of Antennas, R F Components, UHF & Microwave Receivers, Data Processing Equipment, or Video Display; Computer Applications

Salaries fully competitive, commensurate with experience.

*Write in confidence to: Mr. Joseph L. Wool, Div. 60-ME
 Missile Detection Systems Section*

HEAVY MILITARY ELECTRONICS DEPT.

GENERAL ELECTRIC

Court Street, Syracuse, New York

work in the fields of the future at NAA



**TEST
 EQUIPMENT
 ENGINEERS**

If you've been looking for an opportunity to explore new engineering territory, the positions now open in our electronics test equipment group may be right down your alley.

We need engineers to do research and development based on an entirely new electronics test equipment philosophy. Briefly, the job involves design of test equipment and analysis of electronics designs submitted by vendors and subcontractors. This is one phase of our work on advanced weapon systems B-70 and F-108.

A BSEE, plus experience, can qualify you.

For more information please write to: Mr. P. E. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 15, Calif.

THE LOS ANGELES DIVISION OF

**NORTH
 AMERICAN
 AVIATION, INC.**



The Applied Physics Laboratory
of
The Johns Hopkins University

Announces Appointments
for
SENIOR SCIENTIFIC STAFF

The Assessment Division of The Applied Physics Laboratory has undertaken new responsibilities and is expanding its Senior Analytical Staff. Senior Scientists in such fields as Mathematics, Physics and Physical Chemistry have in the past proven very effective in solving the types of problems involved which include analyses of tactical situations, the employment of future weapon systems and the application of the most recent advances in science and technology.

Performance of the work requires close association with scientists of other laboratories, operations research personnel of all branches of the Armed Services, and with senior military and civilian personnel.

Studies undertaken by this group will provide guide lines for the hardware research of future years. Staff members are expected to initiate ideas in support of a broad program of National Defense needs and carry them through appropriate analyses with assurance that sound results will be given consideration by the responsible agencies.

The Laboratory's locale, equidistant between Baltimore and Washington, D. C., allows staff members to select urban, suburban or rural living and either of these two outstanding centers of culture as a focal point for fine living.

These appointments offer exceptional opportunities. For information and arrangements for interview, write in confidence to:

Dr. Charles F. Meyer
Assessment Division Supervisor
The Applied Physics Laboratory
The Johns Hopkins University
8617 Georgia Avenue
Silver Spring, Maryland

Engineers and Scientists

The Columbus Division of North American Aviation, Inc. is increasing the pace of its engineering program. This expansion has created positions for engineers and scientists throughout the Engineering Department of this completely integrated division.

Research and Development, Production Design, Preliminary Design, and Military Operations Analysis are all fields in which weapon systems development is being accelerated.

Specialized groups in such diversified fields as aerodynamics, propulsion, electronics, structures, and human factors, are at work on production aircraft contracts and future space programs.

If you would like to progress in your engineering specialty and still live in the heart of the nation, you may find your answer at NAA-Columbus.

Write to: **H. Keever**
Engineering Personnel Manager, Box SA-128
North American Aviation, Inc.
Columbus, Ohio

THE COLUMBUS DIVISION OF
NORTH AMERICAN AVIATION, INC.

Home of the T2J Jet Trainer and the A3J Vigilante



Check Employment Inquiry Form on Page 155

Investigating Employment Opportunities?

Want more information about employment opportunities offered by companies advertising in this issue? Then be sure to give complete data about your job interests, experience and education when filling in the "Employment Inquiry" form.

Although not an application for employment, it provides employment managers with information to evaluate your capabilities—and in turn gives your request immediate consideration.

Check the "Employment Inquiry" form for details.

Celestial Dynamics

THE
AEROSCIENCES
LABORATORY
OF
GENERAL ELECTRIC'S
MISSILE AND
SPACE VEHICLE
DEPARTMENT

is concerned with analytical and computer studies of interplanetary and lunar trajectories. Opportunities exist to do creative work in the following fields:

Analytical Dynamics
Applied Mechanics
Applied Mathematics
Celestial Dynamics

Operating within a climate of scientific curiosity, with the most modern equipment available and in association with known authorities, programs in the above fields offer unusual opportunities and contribute significantly on a high professional level.

Advanced degrees requested

Please submit qualifications in complete confidence to

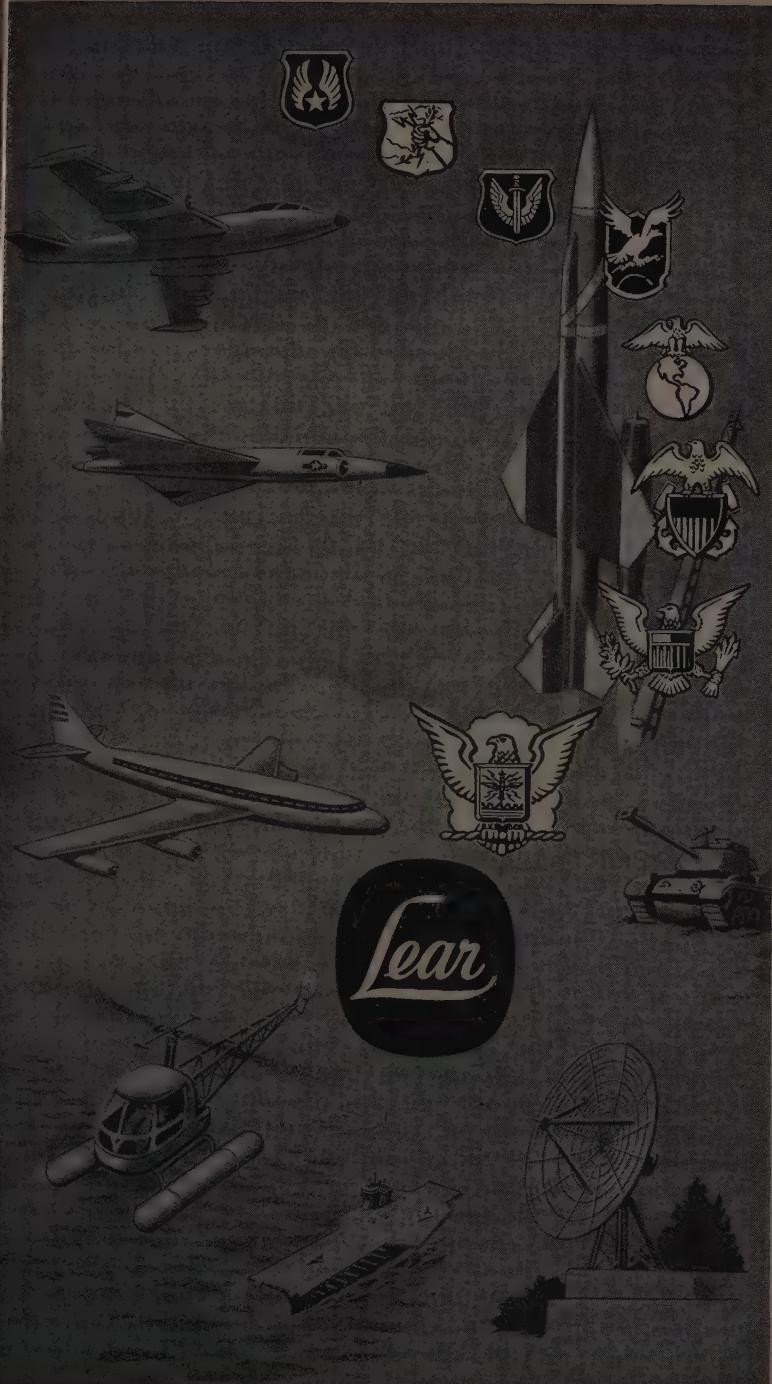
Mr. R. L. Eddy
Department 709-1
Professional Placement

Missile and Space Vehicle
Dept.

GENERAL  **ELECTRIC**

3198 Chestnut Street
Philadelphia 4, Pa.

Check Employment Inquiry Form on Page 155
SPACE/AERONAUTICS



**Expense-paid interviews
All inquiries treated confidentially**

For further information write: **GEORGE E. BROOKS**
Engineering Employment

an invitation to creative engineers...

Here's your invitation to team with Lear, Incorporated, a company which through years of continuous growth while working with the Army, Navy and Air Force has developed a host of new systems and more than 400 current products that are now established in the inventory of new weapons systems.

Lear work includes the fields of guidance systems for interceptor missiles for the Army and Air Force, ASW equipment for the Navy and Marines, and aircraft and missile flight controls for the Army, Navy and Air Force. More Lear-designed attitude indicating systems are operational in U.S. military jets than any other systems of that type.

This wide acceptance of Lear products in military aviation offers you greater opportunities for advancement and challenging assignments. Right now at Lear's Grand Rapids Division, located in a metropolitan area noted for its residential sections, pleasant climate and year-around recreational opportunities, we have openings for:

SENIOR PROJECT ENGINEERS

With 6 years or more appropriate experience in gyro systems engineering, attitude-indicating instruments, stable platform, flight reference systems.

DESIGN & DEVELOPMENT ENGINEERS

Precision mechanisms design and development experience applicable to Rate Gyros, Rate Integrating Gyros, or free, vertical or directional Displacement Gyros.

ELECTRONIC DESIGN ENGINEERS

With 3-5 years or more experience in vacuum tube or transistorized circuitry design and development. Background in electronic systems analysis desirable.

ELECTRO-MAGNETIC ENGINEERS

Experience in design and development of electro-magnetic components and sensing devices such as instrument motors, gyro pickoffs, microsyns, synchros, resolvers, potentiometers.

ELECTRO-MECHANICAL ENGINEERS

Experience in design of electro-mechanical mechanisms, servo positioning systems, electronic circuitry or packaging.

LEAR, INC.

110 IONIA AVE., N.W.
GRAND RAPIDS, MICH.



FOR A SCIENTIFIC CLIMATE...

There's a devotion to creative thinking that you sense the minute you walk through the front door of the Bendix Systems Division.

Located in Ann Arbor, Michigan—a university town with big city advantages—you may enjoy all four seasons to the fullest. The year-round sports and outdoor recreation mean fun for you and your family. Within the buildings that house the Bendix Systems Division, the climate is scientific all year 'round.

If you are an able engineer or scientist seeking to apply your imagination and ingenuity to the problems involved in developing

new weapons systems, you will enjoy the scientific climate at Bendix Systems Division.

If you are interested in doing advanced study, you will find the University of Michigan's fine Engineering College next door. Bendix encourages you to take advantage of this opportunity by attending day-time classes.

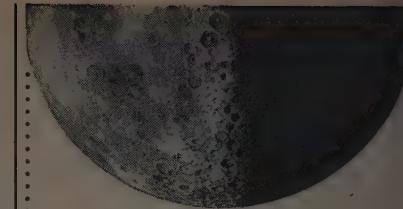
For information on a career in systems research and development, as well as a better way of life, you are invited to write for our new recruitment brochure. Bendix Systems Division, Dept. J5, Ann Arbor, Michigan.



Bendix Systems Division

ANN ARBOR, MICHIGAN

Check Employment Inquiry Form on Page 155



The future begins with

Rocket Engine Design

The man who grows fast in this field is this kind of man:

- strong mechanical ability
- creative imagination
- sparks new ideas
- works hard, takes responsibility
- gets the job done despite obstacles
- extremely interested in rocket engines

If you're this kind, these immediate openings may be the opportunity you've been looking for:

SENIOR DESIGN ENGINEERS to design high pressure storage vessels and related pressurizing systems. Experience in the design of high pressure tanks and similar systems, such as high pressure plumbing and duct systems. A degree in mechanical engineering and experience in rocket engine design or aircraft powerplant and airframe design are desirable.

Please write to **F. E. Jamieson**, Engineering Personnel Dept., 6633 Canoga Ave., Canoga Park, Calif.

ROCKETDYNE 
A DIVISION OF NORTH AMERICAN AVIATION, INC.
FIRST WITH POWER FOR OUTER SPACE



Check Employment Inquiry Form on Page 155
SPACE/AERONAUTICS

HIGH-LEVEL ENGINEERS

to work on exciting new
ANTI-MISSILE PROJECT

in sunny San Diego

Brilliant ground-floor opportunities in the fields of:

FLUID SCIENCES	FLIGHT MECHANICS
DYNAMICS	STRUCTURES
AIRBORNE RADAR SYSTEMS	

Solar's new ARPA Project involves a completely new system of anti-missile defense. It is the latest of several highly advanced projects of Solar's Missile and Space Group. The right men joining now will get in on the ground floor and gain key creative positions in their fields of interest. It will be to your advantage to learn complete details immediately.

SOLAR SPECIFICS

Solar is a medium-size company (2500 people in San Diego) with a successful history since 1927. It is big enough to offer the most advanced personnel policies, yet small enough so you don't get lost

in the crowd. Salary and performance reviewed semi-annually. Liberal relocation allowances. Solar is making many significant contributions to space-age technology, and the special professional status of engineers is fully appreciated and recognized. A new 60,000 sq. ft. engineering building, necessitated by expanding research and development, will be completed in 1959 on the edge of San Diego Bay.

SEND RESUME

Please send resume of your qualifications at the earliest opportunity to Louis Klein, Dept. E-400, Solar Aircraft Company, 2200 Pacific Highway, San Diego 12, Calif.

SOLAR
AIRCRAFT COMPANY



SAN DIEGO
DES MOINES

LIVE BETTER, TOO! In addition to greater opportunities for personal achievement, Solar also offers you the chance to live better in sunny San Diego. This famous resort area has the finest year-around climate in the U.S. Cultural, educational and recreational facilities are excellent. The new Advanced Sciences Branch of the University of California offers facilities for further study. You and your family will enjoy life more at Solar in San Diego.



One of the 20th century's most significant events is the countdown at Cape Canaveral. And participation in the countdown, and in the planning and preparation that precedes it, and in the test data collection, reduction and evaluation that follows, is the job of the Pan Am engineer.

Our Guided Missiles Range Division acts as prime contractor to the Air Force for management, operation and maintenance of the 5000-mile Atlantic Missile Range. Thus each member of our technical staff has a unique opportunity to play an intimate, vital role in the nation's major missile test and aeronautical exploration activities.

Certainly other creative engineers will find no greater challenge for professional achievement than on this threshold of the space age, in Florida, with Pan Am. If you are one such man, with a degree in engineering, mathematics or physics, we invite you to investigate our career openings by addressing a brief resume (in strictest confidence) to our Director of Technical Employment. His name follows.

MR. J. B. APPLEDORN
Pan American World Airways, Inc.,
Dept. T-5.
Patrick Air Force Base, Fla.



GUIDED MISSILES RANGE DIVISION
PATRICK AIR FORCE BASE, FLORIDA

work in the fields of the future at NAA



COUNTER-MEASURES ENGINEERS

Work on America's most advanced weapon systems.

At North American Aviation, such top-level projects as the B-70 and F-108 weapon systems have created unique careers with a tremendous engineering potential.

We have immediate openings for specialists and systems engineers in the field of electromagnetic and infrared countermeasures. Specialized areas include high power traveling wave tube analysis, receiver techniques, system logic, infrared systems design, and antenna and radome development. Experienced engineers are needed to establish requirements for countermeasures systems and to evaluate new components and techniques and their application to advanced systems.

Minimum requirements are actual experience in countermeasures plus B.S. degree in EE or Physics.

For more information please write to: Mr. P. E. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 45, California.

THE LOS ANGELES DIVISION OF

NORTH AMERICAN AVIATION, INC.



ENGINEERS • SCIENTISTS

*Seek and Find
Daring New Goals
and Rewards with
General Electric's
Growing*

FLIGHT PROPULSION DIVISION* in Cincinnati

(formerly Aircraft Gas Turbine Division, recently renamed to match its expanding product goals)

Our engineers and scientists enjoy the daily challenge of new and stimulating technical problems in the largest number of advanced propulsion system projects in our history. Men with imagination and ideas are needed as Managers and Specialists in:

- ... high Mach powerplants using high energy fuels (Jet Engine Dept.)
- ... commercial jet powerplants (Commercial Engine Operation)
- ... exotic propulsion systems for rockets and space vehicles using plasma and ion power sources (Flight Propulsion Lab.)
- ... developing production techniques for unusual materials and design configurations (Production Engine Dept.)

Advancement opportunities are multiplied—nearly 50% of our professional people earn promotion every year. Our engineering staff has more than doubled since 1955.

● **LOOK INTO NEW POSITIONS NOW OPEN IN OUR 4 DEPARTMENTS IN CINCINNATI for Graduate Engineers and Scientists**

Vibration/Mechanical Analysis
Cycle Analysis
Combustion Engineering
Control Mechanical Design
Mechanical Design
Reliability
High Energy Fuels
... and many others.

(U.S. Citizenship Required)

For further information on the opportunities that will let you use your talents better, send your resume to Mr. Mark Peters, Bldg. 100, Dept. 60-MB.

FLIGHT PROPULSION DIVISION

GENERAL ELECTRIC

Cincinnati, Ohio

IMPORTANT

In filling out "Employ-

ment Inquiry Form" be

sure to print clearly.

When you check more

than one company, the

form must be photo-

stated so that each

company receives a

copy.

For more
detailed
information...
on Products
or Service
use this
"TIME-SAVER"
Card

1. Write reader service number for each editorial item or advertisement of interest in box on card. (Reader service numbers appear next to all editorial items and advertisements.)

2. Fill out your Name, Title, Company, Address and check industry activity.

3. Tear out and mail . . . no postage necessary. SPACE/AERONAUTICS' Reader Service Department will contact the manufacturer for you.

NAME _____ TITLE _____
COMPANY _____
ADDRESS _____
CITY _____ STATE _____

PRINT READER SERVICE NUMBERS HERE

SPACE/AERONAUTICS

Reader Service Card

MAY 1959

(Not good after 7-15-59)

Does your work apply to:

(Check appropriate box or boxes)

AIRCRAFT PROJECTS

MISSILE PROJECTS

SPACECRAFT PROJECTS

NAME _____ TITLE _____
COMPANY _____
ADDRESS _____
CITY _____ STATE _____

PRINT READER SERVICE NUMBERS HERE

SPACE/AERONAUTICS

Reader Service Card

MAY 1959

(Not good after 7-15-59)

Does your work apply to:

(Check appropriate box or boxes)

AIRCRAFT PROJECTS

MISSILE PROJECTS

SPACECRAFT PROJECTS

NAME _____ TITLE _____
COMPANY _____
ADDRESS _____
CITY _____ STATE _____

PRINT READER SERVICE NUMBERS HERE

SPACE/AERONAUTICS

Reader Service Card

MAY 1959

Does your work apply to:

(Check appropriate box or boxes)

AIRCRAFT PROJECTS

MISSILE PROJECTS

SPACECRAFT PROJECTS

FIRST CLASS
Permit No. 16734
New York, N. Y.

BUSINESS REPLY MAIL

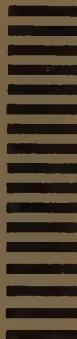
No Postage Stamp Necessary If Mailed in the United States

POSTAGE WILL BE PAID BY

SPACE/AERONAUTICS

205 EAST 42nd STREET

NEW YORK 17, N. Y.



For more
detailed
information...
on Products
or Service
use this
"TIME-SAVER"
Card

Reader-Service Dept.

FIRST CLASS
Permit No. 16734
New York, N. Y.

BUSINESS REPLY MAIL

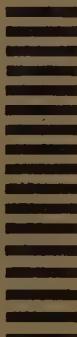
No Postage Stamp Necessary If Mailed in the United States

POSTAGE WILL BE PAID BY

SPACE/AERONAUTICS

205 EAST 42nd STREET

NEW YORK 17, N. Y.



1. Write reader service number for each editorial item or advertisement of interest in box on card. (Reader service numbers appear next to all editorial items and advertisements.)

Reader-Service Dept.

FIRST CLASS
Permit No. 16734
New York, N. Y.

BUSINESS REPLY MAIL

No Postage Stamp Necessary If Mailed in the United States

POSTAGE WILL BE PAID BY

SPACE/AERONAUTICS

205 EAST 42nd STREET

NEW YORK 17, N. Y.



2. Fill out your Name, Title, Company, Address and check industry activity.

Reader-Service Dept.

3. Tear out and mail . . . no postage necessary. SPACE/AERONAUTICS' Reader Service Department will contact the manufacturer for you.



product index to advertising

THIS IS A SPECIAL REFERENCE to the product information given in the advertisements in this issue. It is intended solely to help the reader make the best use of these ads. Therefore the index does not necessarily cover all the products made by each advertiser. Also, cross-listings are not intended to exhaustively describe each product but merely to make sure that each product can be found with reasonable ease by the reader looking for it.

Similar indexes to services and employment opportunities featured in ads follow this index.

Advertisements for which complete proofs were not available to the Editorial Department by the closing date are not necessarily covered by these indexes. (Proofs can be forwarded internally by the Production Department only for advertisements meeting the closing dates.)

For more detailed information on any product or service advertised in this issue or featured in its Product and Data Reviews, use the handy Reader-Service Card.

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ITT Industrial Products Division

ST

IN CUSTOM POWER EQUIPMENT

The Industrial Products Division of ITT offers a complete facility for custom airborne, ground, and ground-support power equipment and systems. Backed by the research, development, manufacturing, and technical experience of the worldwide International Telephone and Telegraph Corporation, we can package power equipment with built-in reliability to your exact requirements. Our complete engineering staff and environmental testing facilities enable us to supply reliable, high-quality units and systems, both quickly and at reasonable cost —

- DC Transformers
- Complete Systems
- T/R units
- High-voltage Supplies
- Partial Systems
- Inverters
- Magnetic Amplifiers
- Transistor-regulated Supplies



20-Amp Silicon T/R used on Chance-Vought F-8U and Douglas A4D-2N.



Launcher power supply for Lockheed's F-104 Starfighter.



Static power unit for this nation's most advanced jet bomber.

Typical ITT Power Units. More than 50 different models of ITT power equipment are proving themselves in use every day.

THE LATEST IN STATIC POWER DESIGN

We have a complete line of fully qualified static power equipment from 20 to 200 amps, in silicon or selenium. No moving parts. Long life — models up to 10,000 hours.

Let us know your requirements... write, wire, or phone.



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INTERNATIONAL TELEPHONE & TELEGRAPH CORPORATION
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ITT provides power source for Convair's B-58 Hustler — a completely integrated electrical power system.

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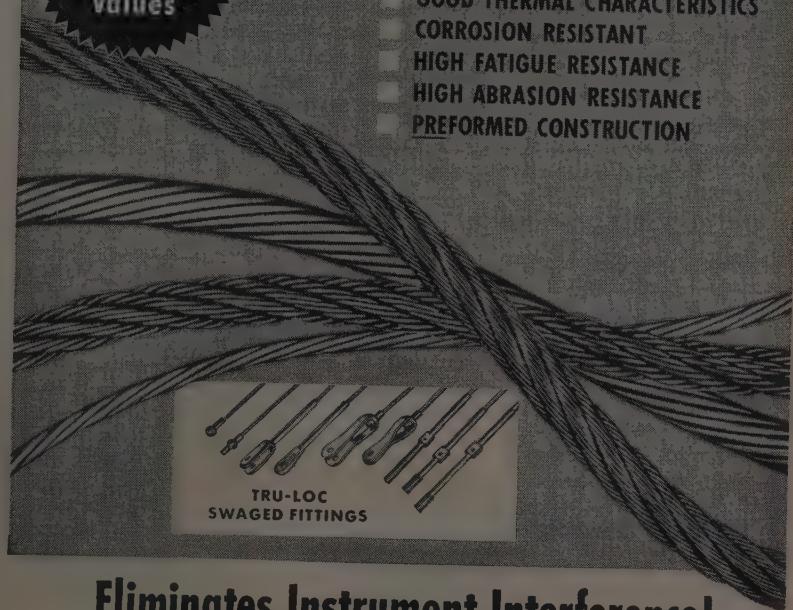
May 1950



NEW "NO-MAG"

NON-MAGNETIC AIRCRAFT CABLES

- GOOD THERMAL CHARACTERISTICS
- CORROSION RESISTANT
- HIGH FATIGUE RESISTANCE
- HIGH ABRASION RESISTANCE
- PREFORMED CONSTRUCTION



Eliminates Instrument Interference!

Just as we expected, many aircraft designers were interested in the recent announcement of our new non-magnetic aircraft cable. If you did not see it, "NO-MAG" has these characteristics:

NON-MAGNETIC PROPERTIES . . .

"NO-MAG" cable is made from type 305 stainless steel. It remains non-magnetic after severe cold working

— in contrast to standard stainless steel aircraft cable which shows a pronounced increase in magnetism after swaging, wire drawing or similar operations.

This non-magnetic property of "NO-MAG" cable eliminates instrument interference from cable magnetism.

CORROSION RESISTANCE . . .

New "NO-MAG" cables have corrosion-resistant qualities similar to, but slightly better than, cables made of standard stainless steel.

GOOD THERMAL CHARACTERISTICS . . .

The thermal expansion characteristics of new "NO-MAG" cable are much closer than those of standard stainless steel or carbon steel cables

to the characteristics of aluminum alloys used in aircraft. This greatly simplifies maintaining cable tension under various changes in temperature.

HIGH FATIGUE RESISTANCE . . .

Preformed construction and careful processing give new "NO-MAG" cable high fatigue resistance.

HIGH ABRASION RESISTANCE . . .

New "NO-MAG" cable shows greater abrasion resistance than standard stainless steel aircraft cables.

TENSILE STRENGTH, while lower than that of stainless and carbon steel, is sufficient to enable replacing these, size for size, with "NO-MAG" on many applications where the characteristics of "NO-MAG" are required.

USE WITH SWAGED TERMINALS . . .

Swaged terminals can be applied to standard AN dimensions.

COMPLETE RANGE OF SIZES, CONSTRUCTIONS . . .

New "NO-MAG" is furnished in sizes from 1/16" to 1" in all of the standard aircraft cable constructions.

Get the complete story on this new technical development for the aircraft industry. Write today to Detroit office.

Automotive and Aircraft Division
AMERICAN CHAIN & CABLE

ACCO



601 Stephenson Bldg., Detroit 2
6800 East Acco Street, Los Angeles 22 • Bridgeport 2, Conn.

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b



c



c

a. Titanium slabs are heated prior to rolling into continuous sheet coils. Crucible's increased capacity for producing high purity metals, in all sizes and mill forms, is substantially reducing costs and delivery times.

b. Vacuum Melted Alloys are specified for gyroscope balls used in navigational and fire direction systems. The metals' improved properties facilitate miniaturization.

c. Titanium helium storage bottles for ICBM Atlas. Titanium, which must be vacuum melted, was selected because of its high strength weight ratio, cold-resistant properties and corrosion resistance.

d. **Basic Melting Processes.** Vacuum induction melting produces "purer" metals than conventional air melting because it eliminates all sources of contamination except the crucible. Vacuum arc remelting eliminates the crucible and permits production of ingots up to 18,000 lbs.



VACUUM MELTING CREATES

Marked improvements in properties produced by High-Purity Metallurgy

Behind the development of space-age metals with entirely new characteristics is vacuum melting — a series of processes that produce "purer" metals with better properties.

Why Vacuum Melt? Vacuum melting protects molten metal from contact with air. It also provides closer control of composition, helps eliminate inclusions, and minimizes center porosity and segregation in ingots.

In the field of vacuum melting, Crucible's position is unique. As the leading producer of special purpose steels, Crucible's experience in high-quality steelmaking is unsurpassed. Through formerly affiliated companies, now fully integrated with it, Crucible led in the development and commercial production of vacuum-melted steels, iron, nickel, copper — and titanium. Therefore, Crucible's breadth of ex-

perience, together with its extensive facilities, places the company in the best position to provide the "super quality" metals most suitable for a given application.

The three vacuum-melting processes — One of the Crucible processes is — *vacuum induction melting*. It starts with very high-purity raw materials and produces extremely pure ingots. A second is VAR — *vacuum arc remelting*, the consumable electrode process. This process, starting with air-melted electrodes, produces large ingots — up to 32" diameter x 18,000 lbs. It pro-



SUPER-DUTY METALS

metal with low-gas content and greatly improved uniformity of properties. The third process is VIR — *vacuum arc remelting of vacuum induction melted electrodes*—a double-melting technique. It permits manufacture of super-pure metals in the full range of ingot sizes.

Crucible's experience with all three processes, and its facilities for vacuum arc remelting its own specially air- or

vacuum-melted electrodes, provides industry with a complete range of vacuum-melted metals at the lowest possible cost. Only at Crucible is there available this experience, flexibility and the facilities for vacuum-melting titanium, super-alloys, heat-resisting alloys, bearing steels, tool steels, stainless steels, electronic alloys and nuclear reactor materials.

If you'd like to know more about Crucible's work in High-Purity Metallurgy, read: "Quality Aspects and Properties of Vacuum Induction Melted and Vacuum Arc Remelted Steels and Super Alloys" and "Titanium for Aircraft and Spacecraft". Write: *Crucible Steel Company of America, Dept. AE18, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

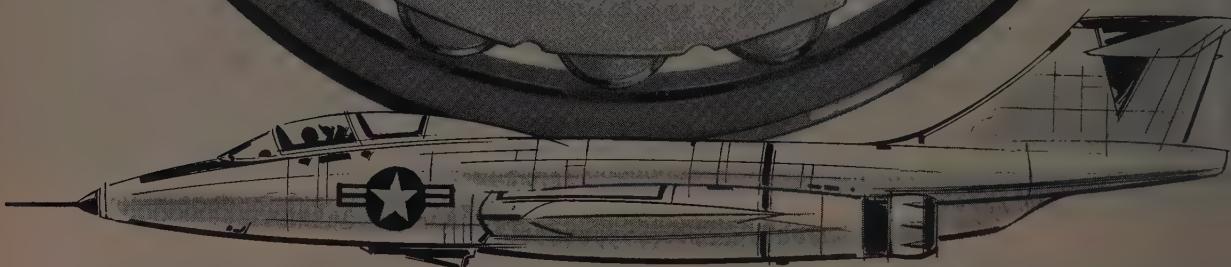
CRUCIBLE

STEEL COMPANY OF AMERICA

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**THE SKY'S
THE LIMIT WITH
HYATT HY-ROLLS
IN
AIRCRAFT
ENGINES**



HYATT HY-ROLL BEARINGS have first call in the specifications for today's most advanced aircraft power plants. Across the entire speed range, HYATT bearings always deliver precision dependability. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

Another  contribution to aviation progress

HYATT **Hy-ROLL BEARINGS**
FOR AIRCRAFT INDUSTRY

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Here's real
FASTENER POWER
KAYNAR: 160,000 PSI

It's here...a powerful, new Kaylock line...now a whopping 160,000 psi! Smallest, lightest, strongest all metal self-locking nuts ever made. Tailor-made by KAYNAR for 160,000 psi NAS high tensile short thread screws and bolts.

Latest addition to the KAYLOCK line is the H14 lightweight hex...best wrench clearance for narrow flanges... mightiest lightweight yet!

NEW H14 SAVES MOST IN SPACE • SIZE • WEIGHT

STRONGER—Strength to weight ratios increased up to 210%.

LOWER—Same low height as NAS 679.

LIGHTER—20% to 67% below H10 or NAS679 series hex nuts.

SMALLER—By 2 to 5 socket sizes than standard AN and NAS nuts.

SPACE SAVER—Narrowest flanges. Moves bolt close to load centers for strongest design.

SELF-LOCKING—With patented resilient locking principle.

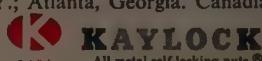
MATERIALS—Available in carbon steel for 550°F. applications. These configurations also in AMS6304 and A286 corrosion resistant steel.



FOR COMPETITIVE REASONS re-appraise your projects with an eye to "trimming off the fat." Send today for Kaynar's new full-line brochure of 160,000 psi self-locking nuts.

KAYNAR MFG. CO., INC.—KAYLOCK DIVISION

World's largest and oldest manufacturer of lightweight, all metal self-locking nuts. Home office and plant: Write Box 2001, Terminal Annex, Los Angeles 54. Branch offices, warehouses & representatives in Wichita, Kansas; New York, N.Y.; Atlanta, Georgia. Canadian Distributor: Abercorn Aero, Ltd., Montreal, Quebec.



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equipment briefs



PRECISION COMPRESSION SPRINGS

DESIGNED for instrument control engineers, these new compression springs offer a major advantage over coil springs, says Consolidated Controls Corp., Bethel, Conn. The spring rate from zero load up remains uniform, since the effective length of turn does not change with load.

The spring designs are manufactured in two basic classes identified as the "herringbone" and "gimbal." Both classes are ma-

chined, heat-treated, and precisely ground to offer perfectly square ends, tight control of free length, and exact matching of specified spring rate.

The units are so constructed as to eliminate completely the twist, or turning, moment between the end faces. The "herringbone" design occupies less volume than the "gimbal" construction. Write in No. 54 on Reader-Service Card for more information.

RADAR TARGET SIMULATOR

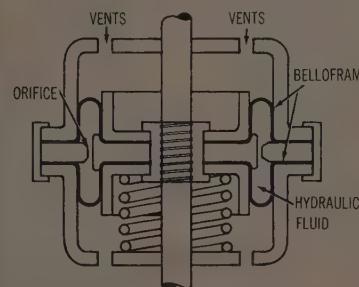
SIMPLER preflight radar checkout is claimed for a microwave target simulator produced by Remanco, Inc., 128 Broadway, Santa Monica, Calif. The Remanco RTS-100 is a complete radar test set made up of two packages: MTG-100X microwave target generator and RP-175 moving video target simulator. Together, they require about 21 ft. of standard 19-in. rack panel space.

Operating in the X-band, the MTG-100X provides a delayed target to a pulse radar at its microwave frequency. The radar main

bang furnishes both time and frequency information for the target pulse. For the operator's convenience, the target pulse is AFC'd to the radar frequency. One-knob tuning allows rapid, positive control of frequency lock.

Used with the RP-175, the MTG-100X becomes a microwave moving target with wide dynamic range capabilities. Testing at either RF or video levels can thus be done in one equipment. Realistic tests can be made of entire fire control systems, including range computers and displays. Features of the stand-

ard unit are continuously adjustable target velocities of up to 5000 fps, accelerations of up to 30 g, and ranges of up to 30 miles. Write in No. 72 on Reader-Service Card for more information.



PISTON SEAL FOR DAMPING

THE bellows-diaphragm seal used in this damping unit was developed by Bellofram Corp., Blanchard Rd., Burlington, Mass. According to the company, it operates easily on pressures up to 500 psi and at temperature of -100 to +550 deg F.

A modified version of this damping unit is being used as a rocket test pad shock absorber. The cylinder housing is mounted on a firm base. The shaft, or position, is then attached to the object to be "soft-mounted"—in this application, the test frame.

The two Bellofram seals mounted back to back are filled with a silicone fluid. Any downward pressure on the shaft is then resisted by the silicone fluid as it is forced through metering orifices into the lower chamber, truly creating a cushioning effect. When the downward pressure is removed, the spring automatically restores the device to its original position.

Since the seal has no spring gradient of its own, says the company, the spring can be designed to provide any gradient. Seal hysteresis and friction are so low, it is claimed, as to be negligible for any accurate instrumentation application. Write in No. 60 on Reader-Service Card for more information.

more on page 177



HIGH SPEED HANDLING

FLY-AWAY HOIST SPEEDS JET TRANSPORT



This compact, powerful fly-away hoist for the KC-135 lifts an 8,000 lb. load at 10 or 20 fpm... moves it in the plane at 20 or 40 fpm.

Typical of WESTERN DESIGN'S 13 years' specialized experience in aircraft cargo hoisting, transversing and airline baggage lifting, the KC-135 hoist is one of many systems designed and produced for applications which include helicopter rescue, sonar hoisting, litter lifting, bomb and missile loading, fuel hose retraction, and delicate instrument handling. The DC-8, 707, KC-135, B-52, C-124, KC-97, C-47, C-46, DC-6, and RC-121 are equipped by WESTERN DESIGN. For any cargo hoist requirement, ground or air, call WESTERN DESIGN.

usi **Western Design**

DIVISION OF U. S. INDUSTRIES, INC.

Santa Barbara and Montebello, California

Santa Barbara Airport • Goleta, California • Woodland 7-4571

Write in No. 432 on Reader Service Card at start of Product Preview Section

DYNAMIC TESTER

AN ELECTRO HYDRAULIC system for dynamic test loading has been developed by Sanders Associates, Inc., Nashua, N.H. A 12-channel unit has been installed at Martin-Baltimore, and a two-channel unit is soon to be installed at WADC.

The test system can simulate the dynamic conditions of actual flight. It represents a major advance over former methods of structural checkout, according to Sanders, since varied loads can be applied to a large number of separate points and be maintained at their set value regardless of specimen deflection. Up to 70,000 lb of control force can be exerted in each channel.

Loads can be applied in a pre-determined, programmed sequence over a short time. Control signals can also be applied to activate hold, continue, reset, and re-cycle operations.

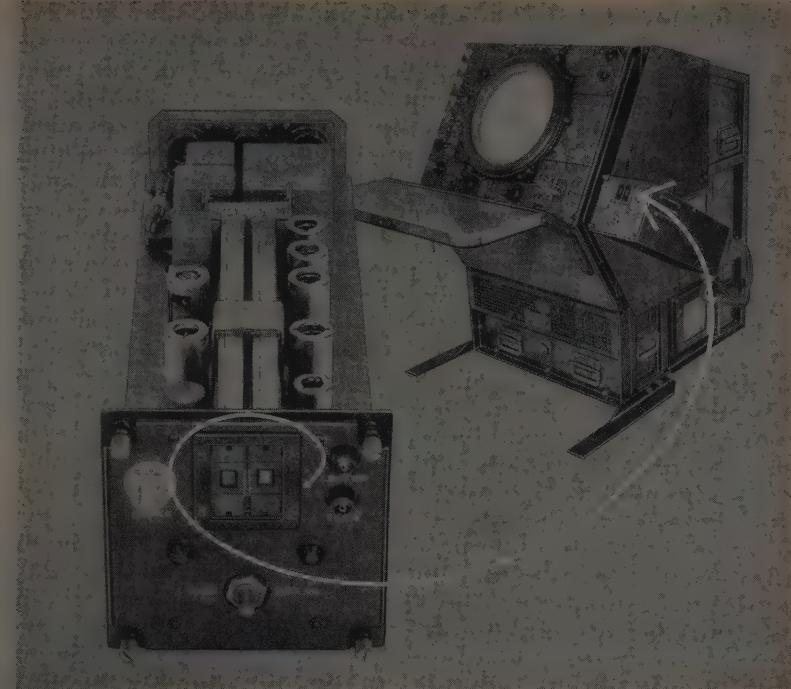
In the electro hydraulic control system, the output from an input programmer is fed into each channel of operation. There the error signal is amplified to control an electro hydraulic servo valve whose output flow is proportional to amplifier output.

A hydraulic actuator operated by the flow imparts the required force to the test specimen. This output force is measured by a force transducer for voltage feedback to the input. When the voltage from the transducer equals the input voltage from the programmer, the error is zero and the required force automatically maintained. Write in No. 62 on Reader Service Card for more information.

PHOTOCOPY CUTS CORNERS

THE duplex photocopy machine marketed by Copepe Corp., 425 Park Ave., New York, N.Y., can reproduce dittoed material, says the company, as well as any original—whether it be printed, written, typed, or drawn in colored ink, pencil, or crayon. Two positive copies can be made from a single negative.

Each reproduction takes about seven seconds. All processing can be safely done under office lighting conditions. Write in No. 58 on Reader Service Card for more information.



Union Indicators help Hazeltine radar-display unit identify aircraft

The little box on the right side of the radar-display unit above warns of approaching aircraft. IFF response is displayed by Alpha-Numerical Indicators, made by Union Switch & Signal. Hazeltine Corporation, Little Neck, N.Y., builders of this unit, chose Union Indicators for their supreme reliability, compact design, and for the other features below:

Two types of Data Display Indicators are made by Union Switch & Signal: Digital, displaying 10, 12, or 16 characters, and Alpha-Numerical, displaying up to 64.

Infinite Retentivity—Both indicators require power only during response time and retain data visually and electrically until a new code is transmitted.

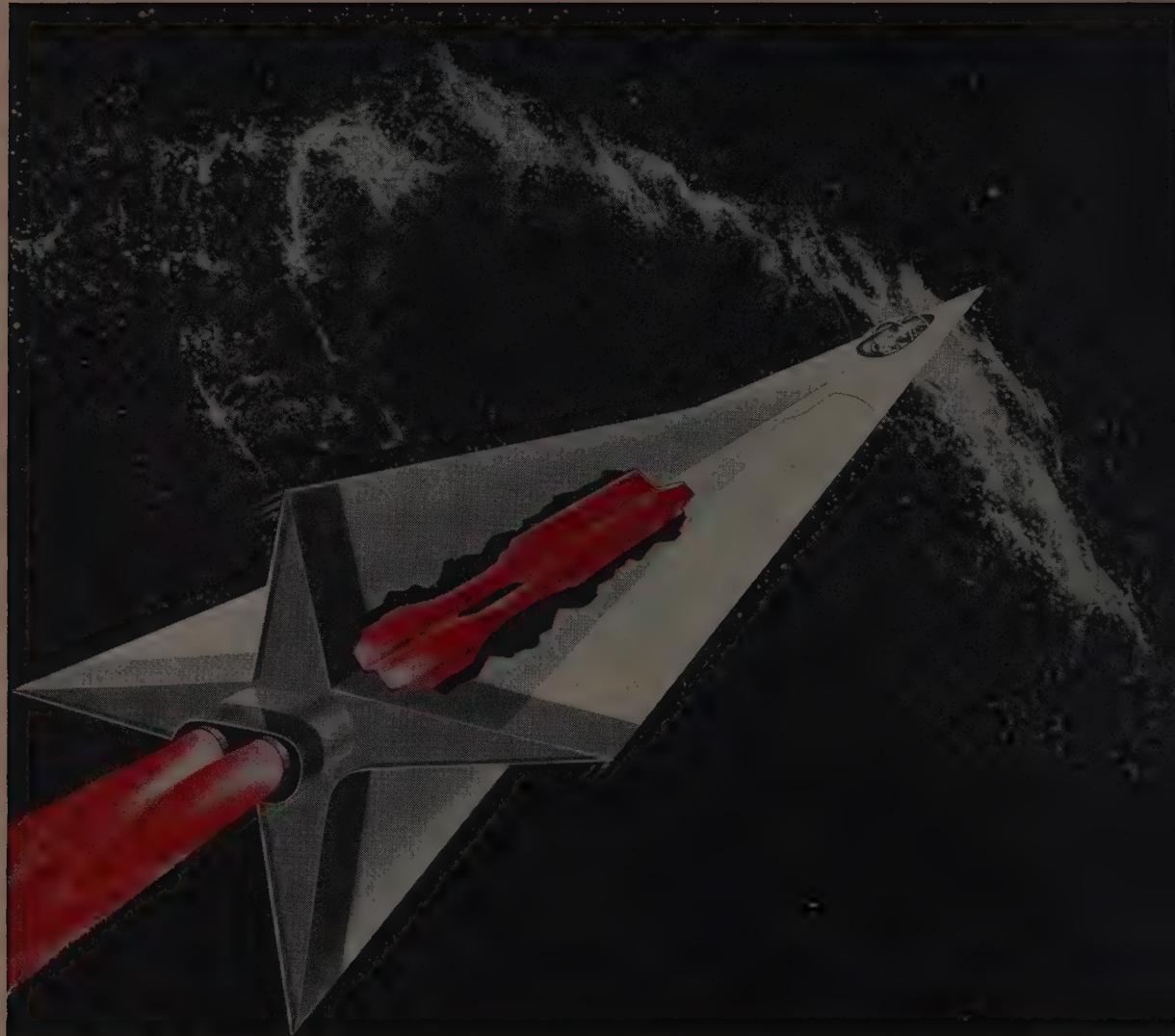
Electrical and Visual Read-Out—Electrical read-out of data is provided in the same form as the input. Data can be read out on a continuous basis without erasing the stored information. Visibility of digital read-out is excellent, even when indicators are mounted in rows. Both indicators operate directly on binary codes on a null-seeking basis, eliminating need for external translation equipment.

Write today for complete information on indicators and other electronic equipment manufactured by Union Switch & Signal.

"Pioneers in Push-Button Science"

UNION SWITCH & SIGNAL
DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY —
PITTSBURGH 18, PENNSYLVANIA

Write in No. 433 on Reader Service Card at start of Product Preview Section



Baby, it's HOT inside

No matter where it comes from . . . ultra-high angular velocities, skin-friction, conduction or radiation from the burners . . . today's airborne bearings spin in temperatures that approach ever closer to the softening point of conventional steels.

Unceasing research work here at Rollway strives for new understanding and control of limiting forces . . . and for practical metallurgical combinations that will enable

aerodyne engines to fly faster, higher and further with less mechanical friction drag.

Rollway service extends all the way from down-to-earth estimates of lead time to closely-held schedules of delivery dates. Maybe we have what you want now on test. Costs nothing to find out. Just write or wire Rollway Bearing Co., Inc., 582 Seymour St., Syracuse 4, N. Y.

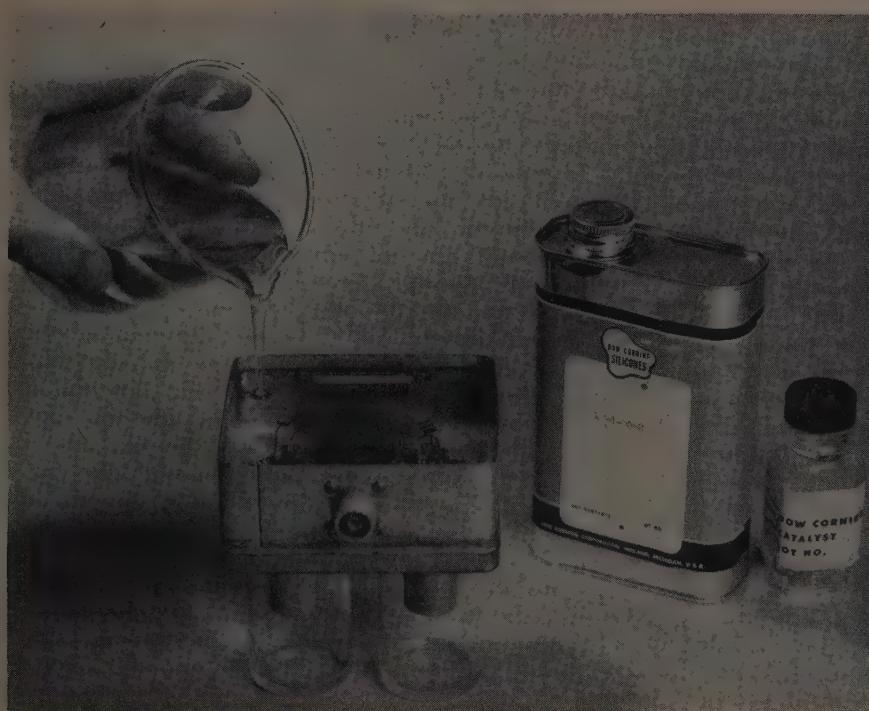


● Typical of Rollway R & D work is this hydraulic control bearing for the McDonnell "Voodoo" jet, featuring a broached, non-separable inner race.

ROLLWAY®
BEARINGS

COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Seattle • Houston • Philadelphia • Los Angeles • San Francisco
Write in No. 434 on Reader Service Card at start of Product Preview Section



**POTTING COMPOUND
is transparent**



MAY 1959

Dow Corning Corp., Midland, Mich., has developed XF 1-0042, a silicone fluid that can be poured into electronic components or subassemblies and gels in place to form a protective, self-sealing cushion. Properly catalyzed and cured, it develops into a soft, colorless, jelly-like mass that has excellent moisture resistance, thermal stability, and dielectric properties comparable to those of electric-grade silicone fluids. The circuits of units filled or potted with this transparent material can be located visually and simply checked by inserting test probes into the silicone gel. As the

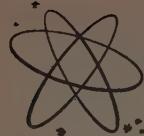
probes are removed from test points, the gel completely reseals itself.

The uncured freezing point is -58 deg F. Volume resistivity is 5×10^{14} at 23 deg C and 1×10^{14} at 150 deg C. Preliminary tests on samples exposed to air indicate that the 1000-hr-operation temperature is between 150 and 200 deg C. Curing time can be varied from about 30 minutes to nearly 48 hours. Curing temperatures range from 40 to 150 deg C. Since XF 1-0042 is an experimental product offered for evaluation only, its properties may be changed to increase its usefulness.

Write in No. 435 on Reader Service Card

This award is made in recognition of outstanding service performed through the development and manufacture of a product contributing to the advancement of aviation.

Randolph Hawthorne
Editor



product preview

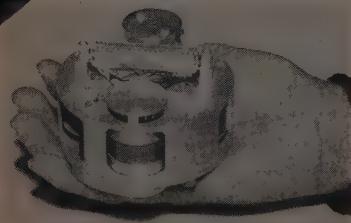
ALLOYS have high heat strength

Alloys with the characteristics necessary for jet engine and missile components are being manufactured by Universal-Cyclops Steel Corp., Dept. S/A, Bridgeville, Pa. They feature high heat strength and corrosion resistance, and are available in the usual forms for engineering steels, including forging billets, sheet, and closed-die forgings.

Among the alloys are Uniloy 1415-NW, a stainless grade ideal for jet engine compressor blades, rings, turbine disks, and similar components. It has a melting range of 2660-2670 deg F and a density of 0.284 lb/cu in.

Write in No. 455 on Reader Service Card

TAPE RECORDER is extremely small



An airborne tape recorder that has seven tape speeds from 0.25 to 15 ips and is small enough to be held in the palm of the hand has been developed by Leach Corp., Dept. S/A, Compton, Calif. The 24-oz, ruggedized unit, said to be the world's smallest tape recorder, has been tested under actual operating conditions for 15-G vibration and 2000-G impact.

Tape widths are $\frac{1}{2}$ and one in. The recorder can be used over -50 to $+200$ deg F.

Write in No. 456 on Reader Service Card

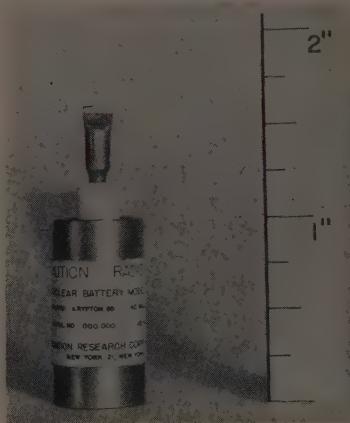
ANTI-SEIZE COMPOUND compatible with lox

LOX lubricant X-1333 is a synthetic that may be safely used for couplings, valves, and other liquid oxygen line parts under any conditions. It has been developed in conjunction with Martin for the Vanguard by Lehigh Chemical Co., Dept. S/A, Chestertown, Md.

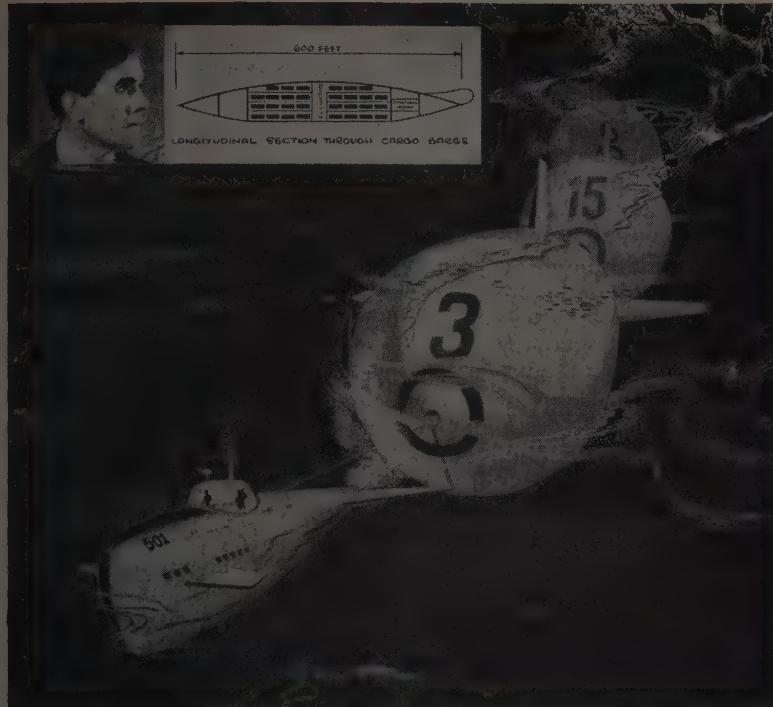
The anti-seize compound is not subject to swift oxidation and subsequent explosion as a result of stress, as are common hydro-carbon-based lubricants under certain conditions. Specification MCI 20202 is based on the formulation, which has its anti-oxidant properties built in.

Write in No. 457 on Reader Service Card

NUCLEAR BATTERY has high output



No. 16 • Mars Outstanding Design Series



UNDERWATER CARGO — P. J. Carroll, M. E., of Dublin, Ireland, has developed this ingenious method of underseas shipping.

The tug, powered by nuclear reaction, tows a string of cargo vessels, taking advantage of ocean currents and sub-polar routes — free from delays due to weather or tides.

Power supply is adequate for years and tug can remain submerged indefinitely. It can transport cargo to and from many ports without surfacing, since based-in-port auxiliary submarine vessels uncouple the cargo carriers from tug and lead them into underwater pens. There cargo, stored in containers, is transferred by elevators and conveyors to trucks which are then sped by nuclear powered mono-rail to principal distribution points.

This nuclear-age concept of shipping is one more example of the contributions that today's designers are making. To help them translate their pace-setting ideas from concept to reality, they require the best of drafting tools.

In pencils that means MARS, long the standard of professionals.



Among the famous imported Mars drafting products are: Left — 1001 Mars-Technico push-button lead holder. Above — 1904 Mars-Lumograph drawing leads, 18 degrees, EXB to 9H. Below — 2886 Mars-Lumograph drawing pencils, 19 degrees, EXEXB to 9H; 2830 Mars-Lumograph Duralar — for drafting on Mylar®-base tracing film — 5 special degrees, K1 to K5; Mars-Lumochrom colored drawing pencils, 24 shades. Not shown — Mars Pocket-Technico for field use; Mars pencil and lead sharpeners; Mars Non-Print pencils and leads.

Mars Products are available at better engineering and drafting material suppliers.

© T.M. FOR DUPONT'S POLYESTER FILM

*for the man
who's going places...*

the pencil that's as good as it looks

MARS

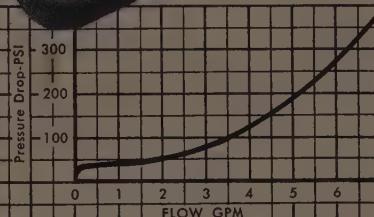
Sold at all good engineering and drawing material suppliers • J. S. STAEDTLER, INC. • Hackensack, N. J.
Write in No. 436 on Reader Service Card at start of Product Preview Section

NEW No-Leak SOLENOID VALVE

- Light Weight — 8 oz.
- Two Way
- Operating Pressure to 3000 psi
- Fluids — MIL-0-5606 and similar fluids



Typical Pressure Flow Curve For Above Valve



• This compact, pilot operated, dependable valve features low power consumption, fast positive response and low pressure drop. Its cartridge type construction simplifies circuit design and permits removal of main valve or the continuous-duty solenoid for easy maintenance. This precision valve is another example of Fluid Regulators' ability to design and manufacture fluid flow and pressure control valves to meet exacting specifications. For immediate analysis of your problem and practical recommendations write:

Designers and manufacturers of hydraulic and fuel valves for aircraft missiles, rockets, ground handling and support equipment.

Fluid Regulators

C O R P O R A T I O N

313 Gillette Street • Painesville, Ohio • Elmwood 2-3319

Write in No. 437 on Reader Service Card at start of Product Preview Section

BALL VALVES have zero leakage

Zero leakage, zero pressure drop is claimed for these larger-capacity ball valves with compact envelopes. In operation, the balanced ball design and specially formed seals have provided zero leakage sealing for liquid nitrogen at -320 deg F at 1200 psig, liquid oxygen at -297 deg F at 1000 psig, and helium gas at 70 to -320 deg F at 2100 psig.

Valves will also handle fuels and acids. Bubble tight performance is claimed over the entire range of standard working pressures, 0-2,500 PSI by Vickery Co., Dept. S/A, 610 Sixteenth St., Oakland 12, and 3312 West Vernon Ave., Los Angeles 8, Calif.

Write in No. 463 on Reader Service Card

SMALL COUPLINGS use helical design



Smooth bearing loads, constant velocity, and absolute zero backlash result from the helical design used in a miniature shaft coupling that weighs only 1/30 oz, says Helical Products Co., Dept. S/A, 1402 The Strand, Hermosa Beach, Calif. The coupling, which is 1/4 in. long and has a 1/4-in. diameter for a 1/8-in. shaft, is ground from one piece of material and has no pins, screws, or rivets.

Couplings for other shaft sizes are available. Special couplings, custom-made from any creep-resistant material, may be provided with integral flanges, gears, clutch and brake components, and shafts.

Write in No. 464 on Reader Service Card

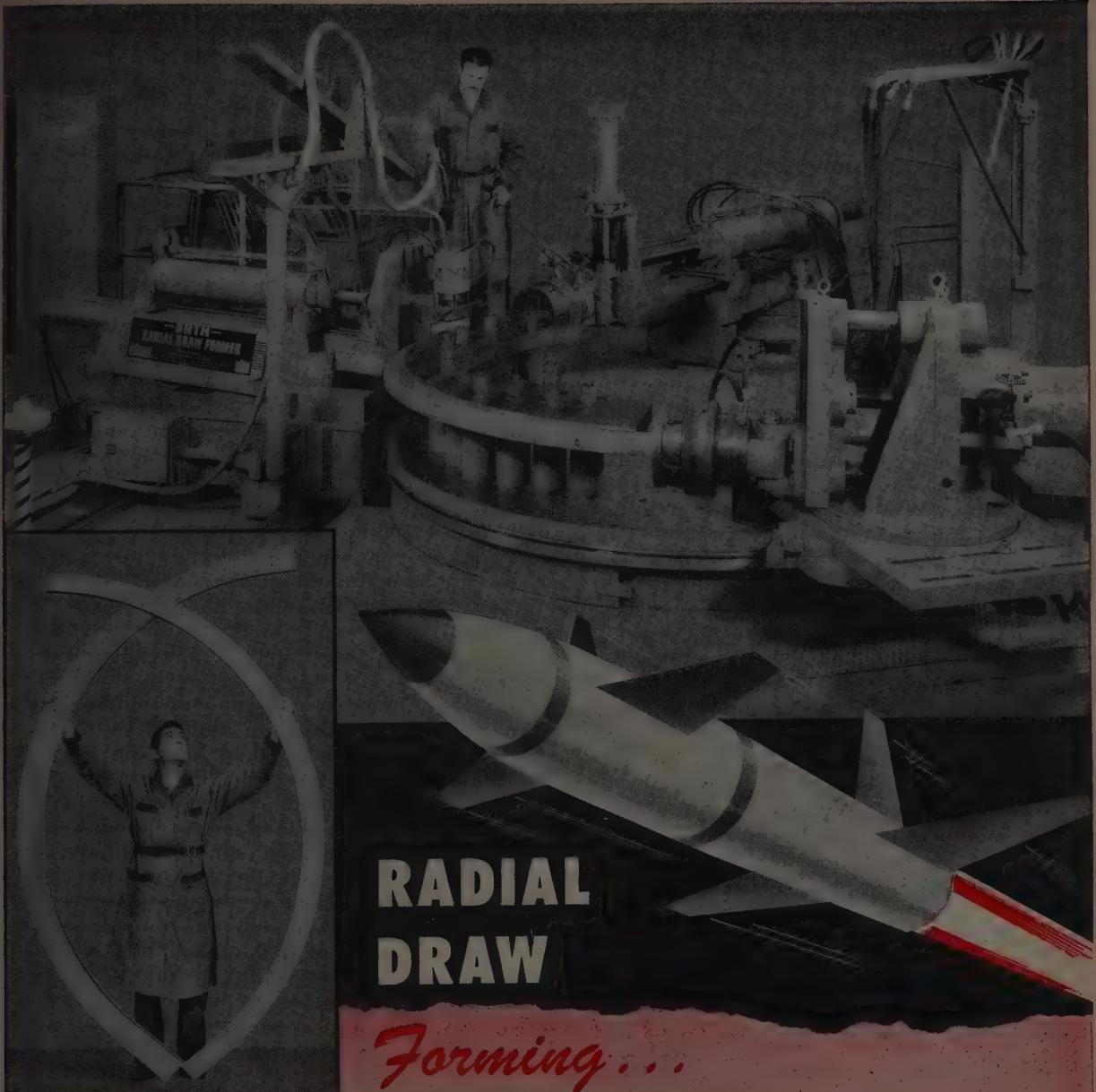
SIGNAL GENERATOR features control circuit

Type 1013 is a signal generator and control system designed for use with graphic readout in automatic frequency response measurements over 200 cps to 200 kc, says B&K Instruments, Inc., Dept. S/A, 3044 W. 106th St., Cleveland, O. The Brüel & Kjaer instrument features a control circuit based on overall system feedback.

The control circuit will override non-linearities in the test system between the point of test specimen excitation and the signal generator. Thus it can regulate signal generator output for constant sound pressure vs frequency to calibrate an unknown sound transducer.

Write in No. 465 on Reader Service Card
more on page 186

SPACE/AERONAUTICS



RADIAL DRAW

Forming...
the big missile shapes

In missile plants across the country and in the BATH Contract Forming Division, RADIAL DRAW FORMERS are producing curved shapes for practically all the major missile programs.

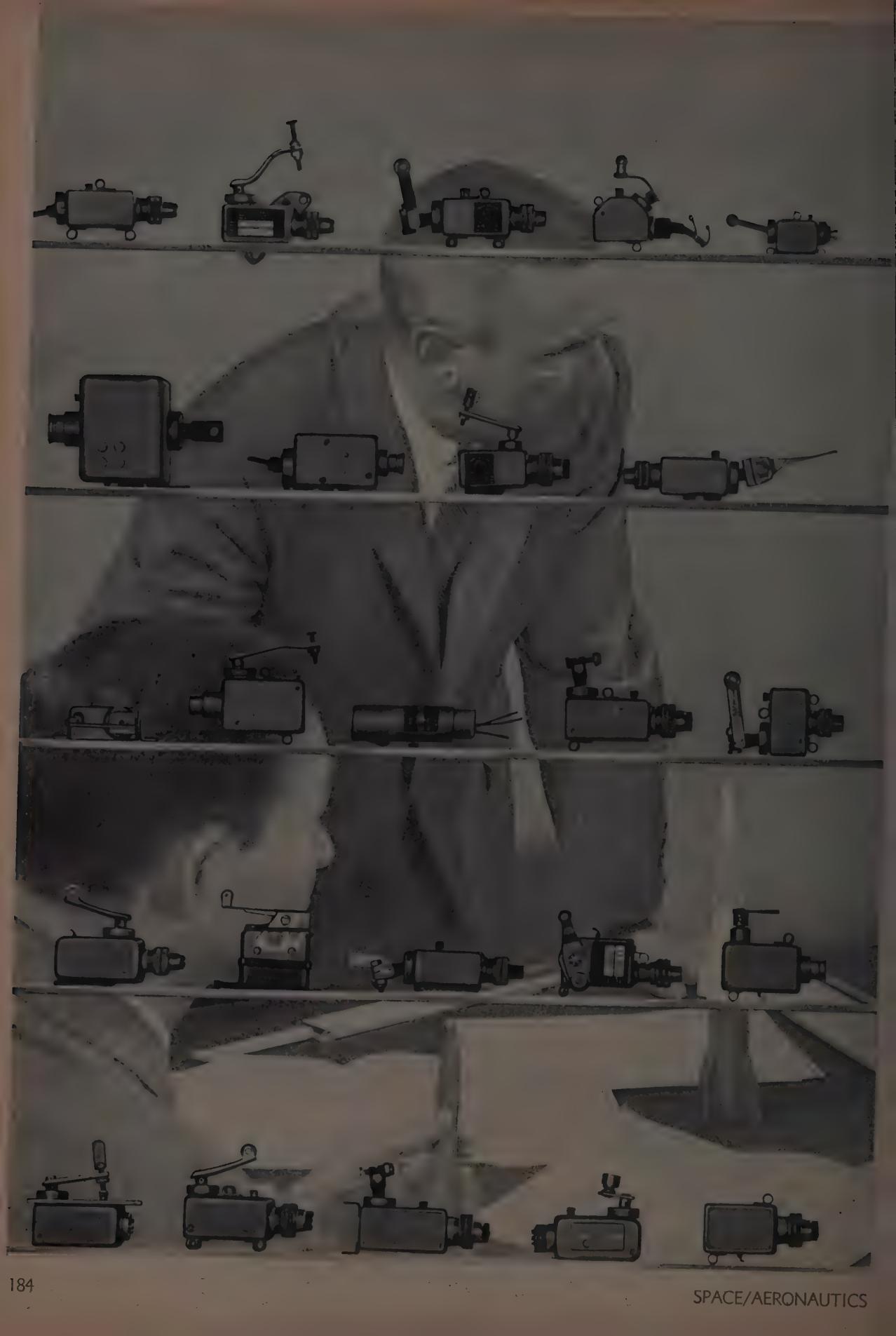
The BATH rotary table design and simultaneous *stretch-form* and *wipe-form* techniques yield large, one-piece parts that are both light and accurate. The new BATH yield-tension control offers extreme accuracy even in today's tough metals. Maximum strength is assured and certified in every part formed.

In missile, jet engine and aircraft production... where accuracy, stability and producibility really count... more and more parts are being formed by the *RADIAL* Draw method. Write for the new catalog number C.F.856 describing BATH Radial Draw Formers or catalog number 32310 describing the facilities of the Contract Forming Division.

THE CYRIL
BATH
COMPANY

32370 AURORA ROAD • SOLON, OHIO
(LOCATED IN THE GREATER CLEVELAND AREA)
Manufacturers of Radial Draw Formers • Dies • Tools
Press Brakes • Tangent Bending Sequence Presses • Press
Type Brakes • Special Machines

Write in No. 438 on Reader Service Card at start of Product Preview Section



in LOX cold or blast-off flame

These special hermetic and environment-free switches were designed to perform perfectly in unusually rugged environments. For example...

An Electrosnap valve position indicator switch for a liquid fuel rocket works reliably on valves handling LOX at minus 300° F.

A major missile uses a specially-designed Electrosnap switch as an interlock or "away" switch, to prevent the missile from being fired when it is not within specified aiming limits. This switch must function within range of the rocket flame.

Absolutely reliable long storage life is a feature of an Electrosnap mass acceleration switch used to cut-in the guidance system on one of our stockpiled missiles.

One of the successful IRBM's has an Electrosnap separation switch which signals for firing Stage Two when Stage One is dropped.

Behind these, and many other hermetic and environment-free switches, are many design conferences where leading missile and aircraft manufacturers developed unusual requirements for switches and controls. And they took their problems to Electrosnap for solution.

As a result, whatever your requirements, we probably already have a standard design that can fill your need. The savings in time and money are yours. If a special switch or actuator is required, we can quickly create or modify a design in any quantity to your specifications. Send us your problem.

Write for complete technical literature on Hermetically-Sealed and Environment-Free Switches.



ELECTRO SNAP CORPORATION

SWITCH DIVISION

4220 West Lake Street

Chicago 24, Illinois

Telephone VAn Buren 6-3100 • TWX CG-1400

Write in No. 439 on Reader Service Card at start of Product Preview Section

HIGH TEMPERATURE subminiature precision snap-acting SWITCHES

YOU CAN USE these new, subminiature switches where positive, snap action — with long life and dependable operation over a wide temperature range — is vital to control circuits. Up to +650°F, or down to -65°F, the UNIMAX Type FC switch provides precise control in small space. Type FC-1 has welding-tab terminals; Type FC-2 has threaded-stud terminals.

A descriptive data sheet will be sent on request. For detailed test data covering temperature characteristics, life, repeatability, and vibration and shock resistance, write — on company letterhead — for Report No. RFC-12.



ELECTRICAL RATINGS

4 amperes, resistive,
at 18-30 volts d-c

2.5 amperes, inductive,
at 18-30 volts d-c

UNIMAX SWITCH

Div. of The W. L. Marconi Corporation
IVES ROAD, WALLINGFORD, CONNECTICUT

Write in No. 440 on Reader Service Card

AMPLIFIER SYSTEM has own power supply

The AC Voltage Amplifier System, Model 10-60, is a seven-channel preamplifier for piezo-electric transducers. Some of its features are: 100 megohm input impedance; 0.4 cps to 200,000 cps bandwidth, one and ten voltage gains (remotely controlled), and full output into 6000 mmf of cable capacitance up to 70 kc. Shock-mounted subminiature tubes are used to obtain high input impedance, and silicon transistors are used to provide high output current capability, says Dynamics Instrumentation Co., Dept. S/A, 1118 Mission St., So. Pasadena, Calif.

The system is designed to minimize ground loop problems since each amplifier has its own isolated power supply with doubly-shielded transformer. All amplifiers are insulated from the cabinet.

Write in No. 466 on Reader Service Card

VANE MACHINE cuts costs

A new vane generating machine for machining vanes and blades takes as little as 10 minutes per blade. The machine is designed to take any vane configuration: straight or tapered sides, concave or convex shapes and constant or variable leads. Vanes can be generated 720 deg and may be perpendicular either to the axis or hub, says Machine Tool Div., Nationwide Engineering Service, Inc., Dept. S/A, 6139 W. Washington Blvd, Culver City, Calif.

The work capacity is six in. diameter maximum and six inches length maximum. Work spindle speed ranges from 0 to 75 rpm, air cutter spindle speed ranges from 18,000 to 35,000 rpm.

Write in No. 467 on Reader Service Card

OSCILLATOR is low cost

A specially designed proportionally-controlled oven system, the RD-140, provides an output frequency stability of better than one part in 10^8 per day for a new, low-cost 0-megacycle crystal oscillator. It consists of a one-tube (6AH6) oscillator assembly, a thermo-oven, which houses the crystal, and an oven control amplifier, says Manson Laboratories Inc., Dept. S/A, P.O. Box 594, 207 Greenwich Ave., Stamford, Conn.

The proportional control system never allows the oven temperature to vary more than 1/1000 of the ambient temperature change. A single element, a temperature-sensitive resistance bridge, is used for oven heating and for sensing temperature change, and eliminates temperature-cycling and oven power-surge. It sells for about \$200.00.

Write in No. 468 on Reader Service Card

GROUND POWER for missile check-out

The Model 2615 motor-clutch-generator set is a 15 kva unit designed for automatic prelaunch check-out of missile systems, according to Varo Mfg. Co., Inc., Dept. S/A, 2201 Walnut St., Garland, Texas. Frequency regulation is 500 cps, ± 0.1 per cent, and efficiency is 60 per cent at 15 kva.

Featured is a control that allows frequency and voltage tracking, as well as automatic load transfer to the missile airborne supply. Automatic synchronization with the supply is also permitted by the control. The Model 2615 incorporates a tuning fork speed control to regulate an electromagnetic clutch between a 60-cps induction drive motor and a 400-cps generator. The device may be skid or trailer-mounted.

Write in No. 469 on Reader Service Card
more on page 188

SPACE/AERONAUTICS



THE GUIDED MISSILE IS A VAST COMPLEXITY OF SYSTEMS FOR GUIDANCE, TELEMETERING, CONTROL, PROPULSION, ETC.

Would you like to know a simple way to build a guided missile?

Sure you would . . . and so would everybody else!

Obviously, there isn't *any simple way* to build a guided missile. And, what's more, there may *never* be one.

But . . . Research and development people just like yours are proving every day that there is a *simpler way*! Constantly, technological improvements are being developed in your own laboratories as well as in laboratories of such organizations as Sciaky.

Sciaky operates the only independent, fully staffed and equipped Research Center dedicated to the development of the resistance welding techniques of fabrication.

That's why the Sciaky Research Center has become a major source to all manufacturers for (1) basic and advanced research, (2) development of experimental tooling and fixturing, (3) assembly of experimental and prototype models, (4) pilot production runs, etc.

Why take less than the full advantage of consulting with Sciaky engineers on your research and development projects. You will receive the full support of (1) the knowledge and experience that has produced almost all the basic technological advances to resistance welding equipment, (2) a complete array of testing and inspection apparatus, and (3) the most unusual collection of the most advanced resistance welding machines of all types, as well as all the other machine shop, fabricating facilities, etc., necessary to a research function of this magnitude.

Write today under your company letter-head for your copy of the facilities brochure describing the Sciaky Research Center in detail. No obligation, of course.



SCIAKY BROS., INC. 4912 W. 67th Street, Chicago 38, Illinois • PORTSMOUTH 7-5600

Write in No. 441 on Reader Service Card at start of Product Preview Section

SEAL-LOCK*

...THE TRULY
REUSABLE FITTING
FOR FLUOROFLEX® HOSE



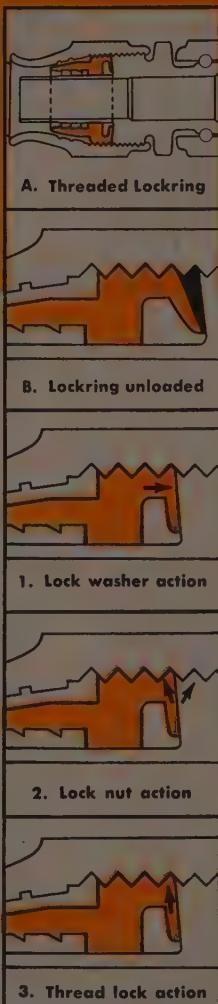
Triple-locked Positively leakproof

- A Threaded lockring grips braid tightly; buried, it's tamper-proof.
- B Before tightening—nipple about to contact coned disk of lockring.
- 1 Tightened . . . spring action of coned disk locks threads in compression.
- 2 Male threads are securely wedged against flanks of female thread.
- 3 Radial displacement of coned disk presses rim against socket wall.

Superior design gives this reusable fitting the same iron-clad safety and reliability as the service-proved Resistoflex factory-swaged fitting. Unique coned disk lockring provides triple lock when nipple is tightened . . . fitting *cannot* leak, *cannot* blow-off.

Seal-Lock fittings are specially designed for fluorocarbon hose. Their reliability is assured by the company with the greatest experience in fluorocarbon hose production. They're CAA approved. Send for bulletin giving full data. Dept. 239 RESISTOFLEX CORPORATION, Roseland, N. J.

*Trade Mark. Pat. applied for.
®Fluoroflex is a Resistoflex trademark, reg., U.S. pat. off.



Originators of high temperature fluorocarbon hose assemblies

Resistoflex

CORPORATION

Roseland, New Jersey • Western Plant: Burbank, Calif. • Southwestern Plant: Dallas, Tex.

Write in No. 442 on Reader Service Card at start of Product Preview Section

PRODUCT PREVIEW

LOW-PASS FILTERS are miniature

These small, low-cost filters have 50 db minimum attenuation at the critical frequency. Attenuation of 25 db or more is maintained as high as 10 times this specified frequency, says T T Electronics, Inc., Dept. S/A, P.O. Box 180, Culver City, Calif.

The bandpass insertion loss falls to 3 db at 0.01 times the maximum attenuation frequency. Rejection frequency as low as 20 cps can be specified for these RC networks. The units are encapsulated in an epoxy resin for stability. The cylindrical package is $1\frac{1}{16}$ in. diameter and $1\frac{1}{2}$ in. high.

Write in No. 470 on Reader Service Card

CATHODE-RAY TUBE is ultra-short



The Type 8YPI $1\frac{1}{2} \times 3$ -in. rectangular CRT can be operated at anode potentials as low as 500 V with vertical and horizontal sensitivities of 26 and 40 V dc per inch, respectively, says Waterman Products Co., Dept. S/A, 2445 Emerald St., Philadelphia, Pa.

Despite its short length of 7 in. overall, the tube has high brightness and can operate with anode potentials as high as 2750 V. The tube is electrostatically focused and deflected. The tube is also available with P2, P7, and P11 phosphors.

Write in No. 471 on Reader Service Card

POWER AMPLIFIER is small and rugged

Abuse from the most rigorous airborne and missile applications will not affect this r-f power amplifier, which measures about $5 \times 3\frac{1}{2} \times 2$ in., says Electronics Div., Rhee Mfg. Co., Dept. S/A, 7777 Industry Ave., Rivera, Calif. The one-lb Model REL-09 HF operates in the 235 to 260 mc telemetering band.

The device delivers an eight-W output to a 52-ohm load, with a 1.4-W input drive. Grid and plate tuning controls are accessible from the front plate. The amplifier is protected against damage resulting from the loss of drive or plate power.

Write in No. 472 on Reader Service Card
more on page 193

The TAP-LOK® threaded insert

...taps its own thread

locks itself in...

in a

single operation!



TAP-LOK inserts provide strong wear-resistant threads in relatively soft machinable materials (wood, plastic, aluminum, etc.) . . . as well as in harder materials where repeated assembly makes excessive thread wear a problem.

Unlike ordinary threaded inserts, however, TAP-LOK inserts cut their own threads in the parent material. Thus, *no additional assembly time is required* with a TAP-LOK insert.

Its installed cost is the lowest of any threaded insert.

The locking action is achieved in this way: the tapered pilot section carrying the thread cutting edges is followed by the full diameter threads which force their way into the parent material. Once installed, a TAP-LOK insert is permanently locked in place.

Available in the types shown below, TAP-LOK inserts can be used wherever threaded inserts are required. Write today for complete information.



Slotted:—Full V-form external threads provide maximum locking-torque; permit wide choice of mating hole sizes. Recommended for soft aluminum, zinc die castings, sand castings, plastics. Class 2B internal thread — MIL-MS 35914.



H-Series:—A heavy walled insert with truncated root external thread and three-hole cutting edges for hard-to-tap higher-strength materials and to meet MIL and other specs calling for Class 3B thread fit for gaging after installation.



W-Series:—Coarse-pitch external thread offers maximum strength; permits installation in small wooden sections without splitting. For furniture, cabinets and other wooden parts where strong, permanent threads are required.



P-Series:—This Tap-Lok insert was designed to eliminate thread wear and renew damaged threads in spark plug sockets in aluminum cylinder heads. It is available from stock for standard plug sizes to meet most needs.

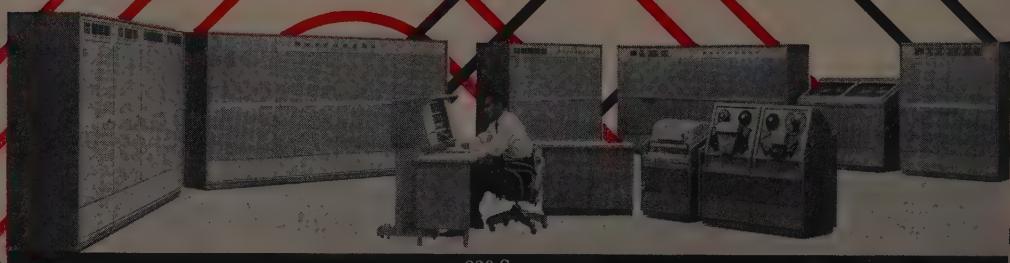
TAP-LOK



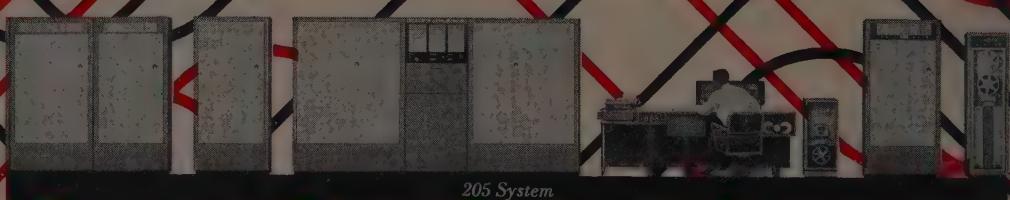
Another fastener development from—
GROOV-PIN CORPORATION

1121 Hendricks Causeway, Ridgefield, N. J.

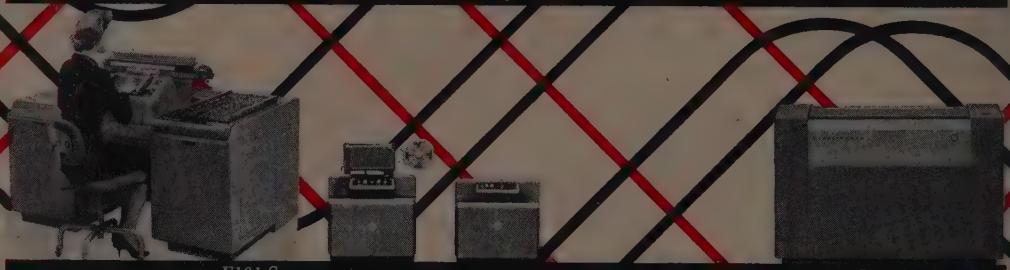
Write in No. 443 on Reader Service Card at start of Product Preview Section



220 System



205 System



E101 System

Datafile



220 High Speed Printer System

Paper Tape Reader/Punch

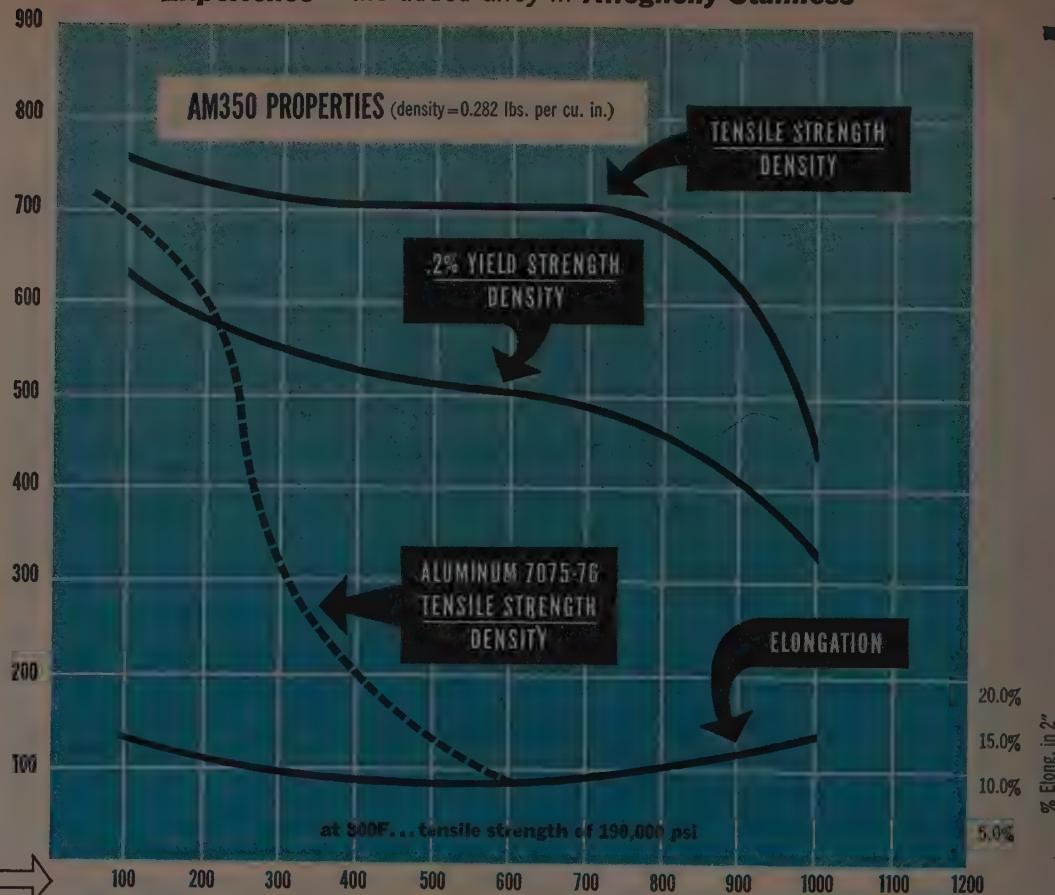
Magnetic Tape Unit

*expandable for growing needs:
a full range of Burroughs electronic computers
for science and business*

From advanced computer systems to individual computer components...the Burroughs line of electronic data processing equipment spans a full range of varied requirements for both scientific and business applications. • Start at the top if your needs call for giant computer ability: The *Burroughs 220*, first and only available medium-priced computer with expandable magnetic core storage...a powerful multi-purpose system which can grow with your computational requirements. The 220 is now at work and delivering effective results at the lowest application cost. • If present application demands are more moderate, investigate the versatile *Burroughs 205*. First in its field with external magnetic tape storage...complete choice of input/output media with flexible, modular expansion, top capacity and speed. The 205 has thoroughly proven its economic value in a wide variety of scientific and business applications. • Most popular of all low-cost computers is the *Burroughs E101*. Exclusive, simple pinboard programming frees engineering man hours, by reducing manual computation time up to 95%. Machine ability is further extended by optional punched paper tape input/output equipment and new punched card input unit. • Burroughs advanced sub-systems include: *Datafile* magnetic tape unit with vast external storage capacity...up to 50-million digits per unit; *Cardatron*...fastest, most powerful card handling system; *220 High Speed Printer System*...a transistorized unit with unmatched speeds up to 1500 lines per minute, on-line or off-line operation. *High Speed Photoreaders*, *Magnetic Tape Units* and other computer system components are also finding wide use in data processing, communications and allied fields. • Currently in production, all these Burroughs products are designed to meet your growing data processing needs...and supporting the entire Burroughs line is an outstanding team of computer specialists for efficient, on-the-spot, technical assistance. Write today for brochure, specifying system or component. • ElectroData Division, Pasadena, California.



Burroughs Corporation "NEW DIMENSIONS/in electronics and data processing systems"



Two for the space age—AL's AM-350 and AM-355 precipitation hardening steels

A unique combination of highly desirable properties describes Allegheny Stainless AM-350 and AM-355 Steels. They combine high strength at both room and elevated temperatures, excellent corrosion resistance, ease of fabrication, low temperature heat treatment, good resistance to stress corrosion.

They are proving the answer to many space age problems. Airframe and other structural parts, pressure tanks, power plant components, high pressure ducting, etc. are all natural missile and supersonic aircraft applications for AM-350 and AM-355.

AVAILABILITY: AM-350, introduced several years ago, is available commercially in sheet, strip, foil, small bars and wire. AM-355, best suited for heavier sections, is available commercially in forgings, forging billets, plates, bars and wire.

CORROSION RESISTANCE: Compared to the more familiar stainless grades, AM-350 and AM-355 resist corrosion and oxidation better than the hardenable grades (chromium

martensitic) and only slightly less than the 18 and 8's. They resist stress corrosion at much higher strength levels than do martensitic stainless grades.

SIMPLE HEAT TREATMENT: High strength is developed by two methods. Both minimize oxidation and distortion problems. The usual is the Allegheny Ludlum-developed sub-zero cooling and tempering (SCT): minus 100F for 3 hrs plus 3 hrs at 850F. Alternate method is Double Aged (DA): 2 hrs at 1375F plus 2 hrs at 850F.

EASY FABRICATION: AM-350 and AM-355 can be spun, drawn, formed, machined and welded using normal stainless procedures. In the hardened conditions, some forming may be done . . . 180 degree bend over a 3T radius pin. Also AM-350 can be dimpled in the SCT condition to insure accurate fit-up.

For further information, see your A-L sales engineer or write for the booklet "Engineering Properties, AM-350 and AM-355." Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa. Address Dept. AV-17.

ALLEGHENY LUDLUM

Export distribution: AIRCO INTERNATIONAL

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

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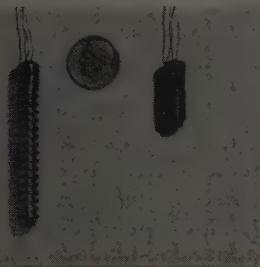
SILICON RECTIFIERS
are rated at 5 amp

A series of silicon rectifiers having peak inverse voltage ratings ranging from 50 to 600 V and delivering 5 amp of rectified current are available from Bendix Aviation Corp., Red Bank Div., Dept. S/A, Long Branch, N.J.

The rectifier package conforms to the latest proposed Vedec standards and are of the diffused-junction type for low forward drop and lower reverse leakage current. EIA has reserved the Jedecl designations IN1612 through IN616 for this series of rectifiers. The operating temperature extends from -65 to $+175$ deg C.

Write in No. 473 on Reader Service Card

BELLOWS MOTOR
works around curves



A reliable, squib-actuated bellows motor that has a 0.320-in. diameter and a one-inch length can be guided around a 90-deg curve, according to Atlas Powder Co., Dept. S/A, Wilmington 99, Del. The unit is capable of a 10-lb thrust over a one-inch minimum stroke within one msec.

One hundred ergs at 1.5 V, or 0.8 amps, are sufficient for actuation. The device will operate properly between -65 to $+165$ deg F and will withstand 20,000 G of shock and acceleration.

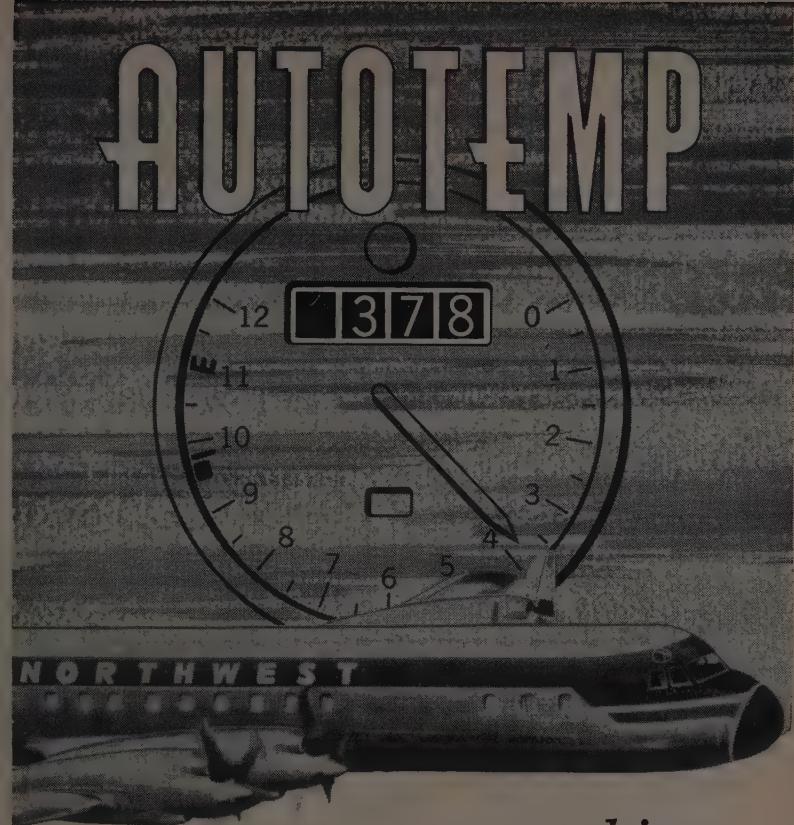
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ACCELEROMETERS
measure two inches

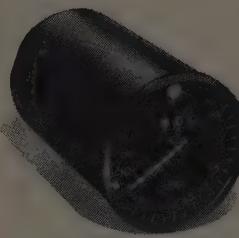
This line of high precision torque generator linear accelerometers measures only two inches in diameter. Very high accuracy is assured in these units through use of torque generator restraints in place of the usual torsion bar. Operated in a closed-loop servo system, precision of the highest order can be obtained, says Reeves Instrument Corp., Dept. S/A, 207 E. 91 St., New York 28, N. Y.

The unbalanced weight is housed in an hermetically sealed cylinder which in turn is fully floated in exact equilibrium in a high density viscous fluid. This floatation process serves to remove all load from the jewelled bearings, while providing viscous damping and shock absorption.

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...now taking
Lockheed ELECTRA'S
temperature...to 1°C.



High accuracy, and easiest *needle pointer plus digital in-line counter readout*, are the principal service features of the BH183 AUTO-TEMP® jet engine temperature indicator.

AUTO-TEMP is designed and produced by the makers of the JETCAL Analyzer®, the only jet engine tester used throughout the world.

*Full information is contained in our Bulletin BH183
available for the asking!*



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actual size
Model HCM 7/16

MINIATURE 7/16" INDICATOR

Micro-miniature moving coil, core magnet indicator; 7/16" diameter, 31/32" length. Weight 10 grams; sealed. Available with a pointer or flag display in a wide variety of electrical sensitivities and functions. Data on request. Marion Instrument Division, Minneapolis-Honeywell Regulator Co., Manchester, New Hampshire, U.S.A.

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"WHERE ELECTRONICS MEETS THE EYE"
meters



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500 WATTS IN FIVE CUBIC INCHES!

... a brand new proportional amplifier only 5 cubic inches in size and .54 lbs. in weight—for missile, aircraft, and ground equipment applications. A 400 cps, 115 volt proportional temperature control unit using silicon control rectifiers in the output stage, it handles up to 500 watts power. Maximum ambient temperature capability of 100°C!

It's exclusive—available now—and ready to solve your space, weight, and power problems!

Write today for complete information:



MAGNETIC CONTROLS COMPANY

6405 Cambridge Street, Minneapolis 16, Minnesota, Dept. 101

Write in No. 449 on Reader Service Card at start of Product Preview Section

The Systems Approach to POWER CONVERSION



The 60 to 400 cycle frequency changing motor generator set and complete controls are mounted together on the skid-base. This smaller type cubical contains all necessary meters, laced and channeled circuitry, motor starter with stop and start push buttons and a Kato static REGOCITER combination voltage regulator and static exciter. Kato Magtrol static regulators are manufactured for use with brushless AC generators which must have rotating excitors.

Investigate Kato's complete line—60 and 400 cycle generators—various speeds—brushless or slip ring types—motor generators for all power converting needs—complete line of controls for all rotating electrical machinery.



Now Kato's complete line of generators is also available in brushless design.

WRITE FOR DETAILS

KATO Engineering Company

1424 FIRST AVE., MANKATO, MINNESOTA

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PRODUCT PREVIEW

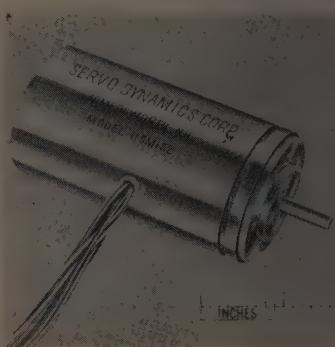
DIFFERENTIAL SWITCH is easy to operate

A differential switch that is basically a small, mechanical assembly used to sense displacement of two shafts has been developed by The Newton Co., Dept. S/A, 52 Elm St., Manchester, Conn. The easily operated device relates a desired shaft position of the 0.25-in. shaft to the 0.125-in. shaft through SPDT center-off contacts.

Actuation of an external circuit by the contacts permits the 0.125-in. shaft to be driven to the position of the 0.25-in. shaft; contacts then become center-off. Direction of contact closure indicates the shortest direction of turn for the desired null.

Write in No. 476 on Reader Service Card

MOTOR GENERATOR works on variable voltage



The Model 11GM152 size 11 motor generator operates between six and 200 V and has a load speed of 6000 rpm with a power input of 3.5 W at 0.053 amp. The generator gradient is 0.5 V per 1000 rpm and has a total null of 0.012 V, according to Servo Dynamics Corp., Dept. S/A, Somersworth, N.H.

Effective resistance of the 1.875-in. unit is 3780 ohms; linearity is 0.5 per cent. The device has an operating range of -65 to +200 deg C and meets the environmental requirements of Mil-T-5422C and Mil-E-5272A.

Write in No. 477 on Reader Service Card

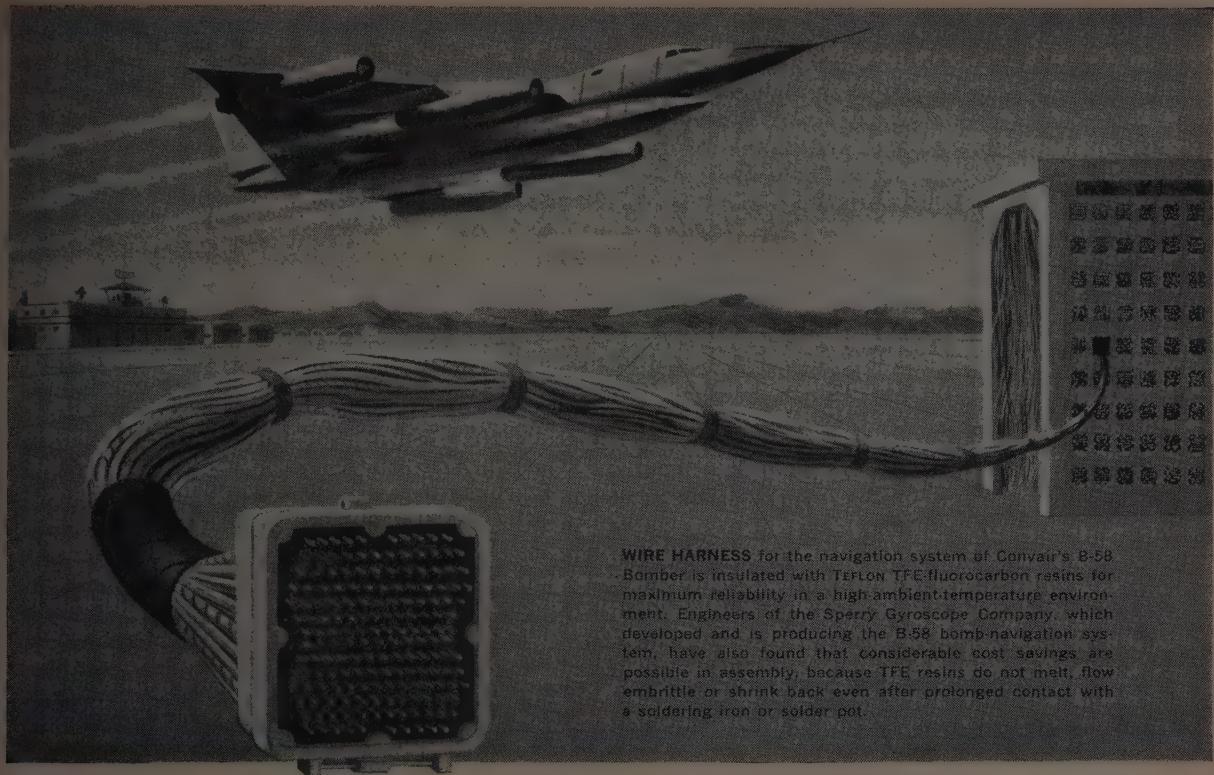
TUNGSTEN CARBIDE sprayed in hard-facing

The hard facing of a number of metal components with sprayed tungsten carbide at a deposit efficiency of over 90 per cent has been made possible by a new spray-powder material, says Metallizing Engineering Co., Inc., Dept. S/A, 1101 Prospect Ave., Westbury, N.Y. The material, developed for use with the Metco Thermospray gun, permits a coating speed of 110 to 150 sq ft/hr, for a 0.001-in. coating.

Any coating thickness may be applied to metal parts subject to extreme wear.

Write in No. 478 on Reader Service Card
more on page 194

SPACE/AERONAUTICS



WIRE HARNESS for the navigation system of Convair's B-58 Bomber is insulated with **TEFLON** TFE fluorocarbon resins for maximum reliability in a high-ambient-temperature environment. Engineers of the Sperry Gyroscope Company, which developed and is producing the B-58 bomb-navigation system, have also found that considerable cost savings are possible in assembly, because TFE resins do not melt, flow, embrittle or shrink back even after prolonged contact with a soldering iron or solder pot.

Wire and cable insulated with "TEFLON" TFE resins withstand continuous high ambients in the toughest services

With **TEFLON** TFE-fluorocarbon resins, you obtain a built-in safety factor. No other wire and cable insulation offers you so great a latitude in overcoming temperature problems and accidental overloads. Wire and cable insulated with these resins are rated for continuous service at 260°C. Yet recent tests have shown that in some cases the useful wire insulation life of TFE resins is greater than 1,000 hours at 350°C. (662°F.) and 100 hours at 400°C. (752°F.). The heat-aging data below shows that even after 6 months at 300°C. (572°F.) the excellent electrical properties of TFE resins are unchanged, and considerable mechanical toughness is retained.

So if reliability is your prime requirement—in assembly, production, storage or service—specify wire and cable insulated with **TEFLON** TFE resins. Often, this is the least costly way to achieve a design objective. See your local supplier of this wire and cable for an engineering approach to your wiring reliability problems.

You'll find him listed in the Yellow Pages under "Plastics—Du Pont". Or, for detailed technical data on these resins, write: to E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept., Rm. T-65 Du Pont Building, Wilmington 98, Delaware. In Canada: Du Pont of Canada Limited, P.O. Box 660, Montreal, Quebec.

EFFECT OF HEAT AGING

Results of oven aging at 300°C. (572°F.)*

Exposure time at 300°C.	Dissipation Factor	Dielectric Constant	Dielectric Strength (volts/mil) ASTM D-149	ELECTRICAL		MECHANICAL			
				MD**	TD***	MD	TD	MD	TD
As received	0.0001	2.03	2930	4970	2100	74	3.8	6780	4790
1 month	0.0001	2.08	2830	3880	2290	71	2.8	5740	3670
3 months	0.0001	2.08	2890	3920	2420	75	3.0	5000	3340
6 months	0.0001	2.11	2950	3540	2320	82	2.5	4150	2430

*5-mil film samples of TFE-fluorocarbon resins

**Tests performed at room temperature following heat aging

**MD—Machine direction

***TD—Transverse direction



TEFLON
TFE-FLUOROCARBON RESINS

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

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TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including the TFE (tetrafluoroethylene) resins discussed herein.

IN HOSE ...WHAT'LL YOU HAVE?



IN-FLIGHT REFUELING HOSE?

Vital feature of the probe and drogue method of refueling is the compact, easy-to-handle hose and integral coupling assembly developed and manufactured by Hewitt-Robins. Aerodynamically balanced hose trails at high speed without wobbling, absorbs tremendous shock loads, and provides maximum safety.

VACUUM HOSE? Exceptional flexibility under extreme temperatures combines with long life in H-R reinforced synthetic rubber or silicone vacuum hose. Lengths and diameters for all high-performance applications.

JET STARTER HOSE? For hot or cold air starts using various elastomers. Also specially designed wire braided constructions for recharging self-contained air bottles.

Hewitt-Robins, prominent in development of aircraft refueling hose, makes many rubber products for the aircraft and missile industries. These components are fabricated using all elastomers, including silicones by themselves or with various fabric or metal reinforcements.

Specialists in our Aircraft Products Department can help you put today's new silicone and rubber compounds to best use in aircraft, missiles, and rockets. For information, service, or your copy of comprehensive Product Bulletins, contact your local H-R representative, or Hewitt-Robins, Stamford, Connecticut.

Ask for Bulletin 5-23



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Write in No. 451 on Reader Service Card at start of Product Preview Section

PRODUCT PREVIEW

ORTHICON TUBE is very rugged

Extreme environmental conditions of shock, vibration, temperature and humidity will not adversely affect the WL-7198 image orthicon tube, says Westinghouse Electronic Tube Div., Dept. S/A, P. O. Box 284, Elmira, N. Y. It operates over a vibration range of 10-g acceleration up to 500 cps and 30-g shock does not impair subsequent tube performance.

The tube provides at least 250 lines horizontal resolution with .0003 ft-c illumination on its photocathode. Horizontal resolution at five-g acceleration, from 50 to 500 cps, is at least 350 lines with .03-ft-c illumination.

Write in No. 479 on Reader Service Card

THERMAL SWITCH is very small



One hundred of the smallest of these chemical-type thermal switches, which have a five-amp rating, weigh less than one oz, says MiniTec, Dept. S/A, 5423 Delaware Ave., Los Angeles 41, Calif. The normally-open, non-repetitive MiniTherm is available with various switching temperatures between 150 and 500 deg F.

One switched, the device holds a closed circuit regardless of temperature changes. It is accurate to ± 2 per cent and will withstand extreme shock, vibration, and temperatures down to -65 deg F.

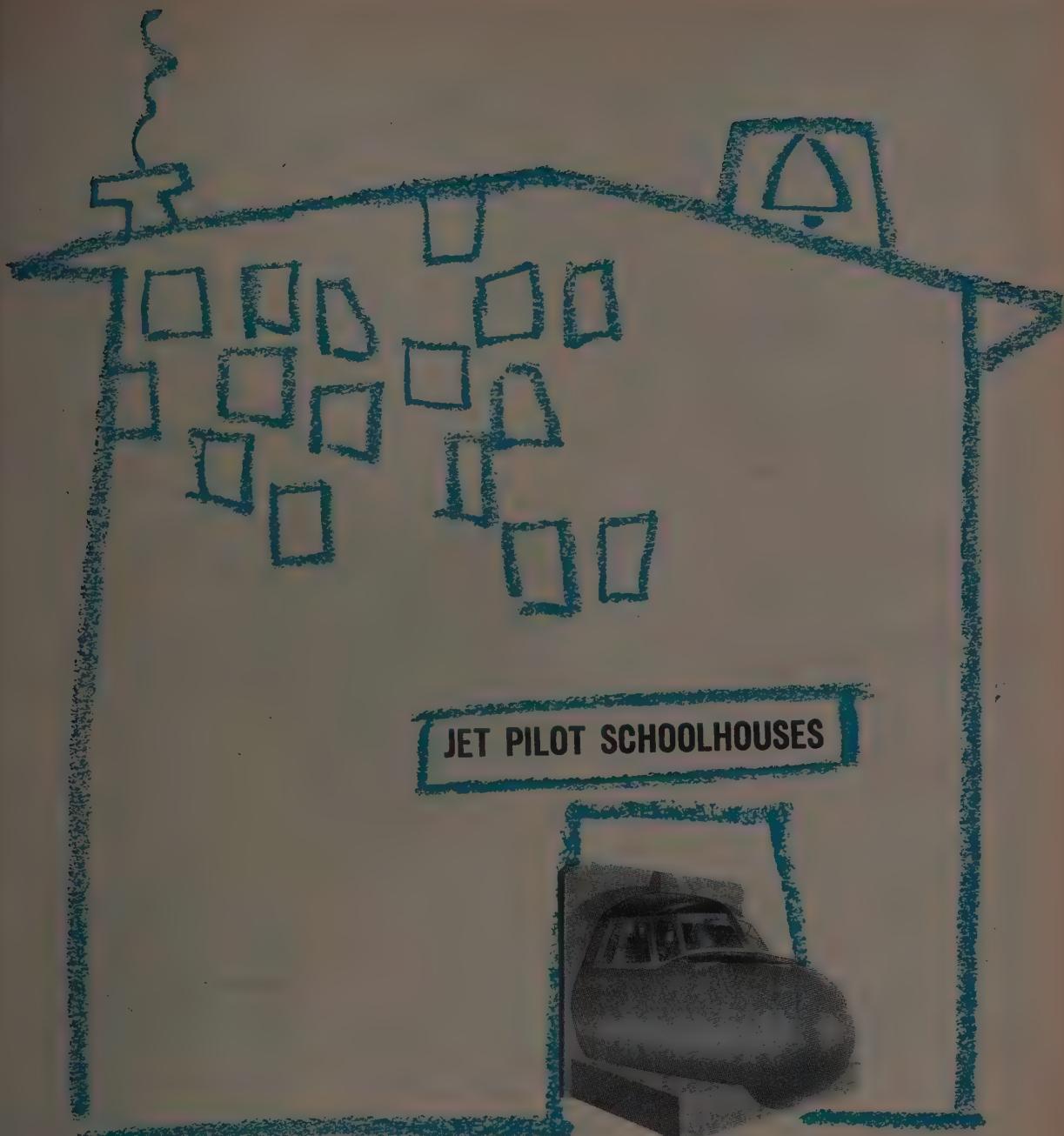
Write in No. 480 on Reader Service Card

TRANSFER PUMP handles liquid fluorine

A transfer pump with an extensive alarm system and damage isolation provisions has been designed for liquid fluorine handling to permit maximum testing with a minimum of hardware hazard, says Aerojet-General Corp., Dept. S/A, Azusa, Calif. The pump, part of a system that includes commercially available throttle and shutoff valves and a tankage pressurization system, will deliver 1000 gpm at a pressure rise of 150 psi.

Pump efficiency is about 55 per cent—somewhat lower than pumps of equal speed, because of the large internal clearances used. At maximum flow, the pump will increase the fluorine's temperature by less than one degree.

Write in No. 481 on Reader Service Card
more on page 198



USE MIDWAY INSTRUMENTS FOR TRAINING RELIABILITY

Accuracy is important in Simulator Instruments too. The tough problems thrown at a jet pilot trainee when he's "flying" a flight simulator call for swift, efficient corrective action. His simulator instruments must indicate the problem accurately and reflect instantly and precisely his remedial procedure.

With the high degree of automated electronic flight, characteristic of the new commercial jets, it is all the more important that the simulator is the place where the new jet pilot learns to respect, and live by, his instruments.

ABOUT MIDWAY

EXPERIENCE . . . Midway has designed and produced hundreds of different types of simulator instruments which are helping to train new pilots for the Boeing 707, Convair 880, DC-8, and Lockheed Electra. **FACILITIES** . . . Its modern air-conditioned plant, engineers and craftsmen are capable of producing to your particular quantity and design needs . . . from a single prototype unit to a full production run.

*Midway is also uniquely equipped to perform specialized services in engineering design, prototype development, and production of custom precision instruments for other applications.



MIDWAY AIRCRAFT INSTRUMENT CORPORATION / 185 BERGER STREET / WOOD-RIDGE / NEW JERSEY
Write in No. 452 on Reader Service Card at start of Product Preview Section

PRODUCT PREVIEW

EXPLOSIVE BOLTS for missile environment

Lightweight, compact, reliable explosive bolts that have been tested under rugged environmental conditions are suitable for missile launcher release, multistage separation, nose cone separation, wing tank jettisoning, and like uses, says McCormick Selph Associates, Dept. S/A, Hollister, Calif. The devices are special or standard bolts with provisions for an integral or separately installed charge.

Arming takes place after bolt installation. The point of bolt separation or failure is reported to be very accurately controlled. Bolts and bolt cartridges are available in fragmenting and non-fragmenting design.

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MC
for HYDRAULIC,
PNEUMATIC, FUEL
COMPONENTS



This

MC 2004-20 COMPRESSOR

as our many other products, can be adapted to your particular need while retaining the Reliability built in by us through design, processing, production, final quality control, and delivery.

M.C. MFG. CO.
P.O. Box 126
LAKE ORION, MICH.

Write in No. 453 on Reader Service Card

CONTAINER holds refueling gear



Light weight and resistance to impact damage are featured in a fiberglas laminate storage and airshipment container for air-to-air refueling accessories, says Harco Container Div., Harbor Boat Building Co., Dept. S/A, Terminal Island, Calif. The 65-lb, 37-in.-diameter container is designed for packaging drogues, hoses, and adapter fittings.

A quick-release V-band is used to hold together the two halves of the container.

Write in No. 483 on Reader Service Card

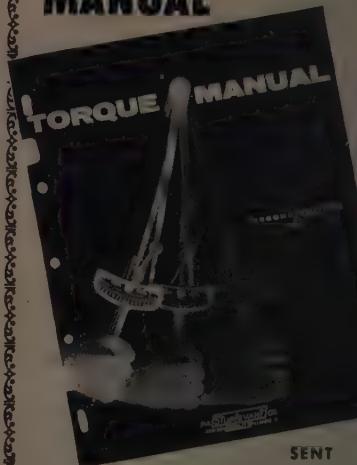
SPECTRUM ANALYZER uses third-octave filters

True rms and average and peak readout can be switch-selected on this $\frac{1}{3}$ -octave type audio frequency spectrum analyzer, says B&K Instruments, Inc., Dept. S/A, 3044 W. 106th St., Cleveland, O. Center frequencies range from 40 to 32,000 cps, with additional low range filters available.

Characteristics of the 30 filters include: tops flat within $\pm\frac{1}{2}$ db; steep sides with maximum slope of 120 db per octave; and skirt selectivity greater than 50 db per octave. The Model 2110 analyzer can be used with the Model 2304 level recorder for an automatic spectrum analysis plot on a frequency-amplitude-calibrated chart.

Write in No. 484 on Reader Service Card
more on page 202

"TORQUE WRENCH" MANUAL



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UPON REQUEST

Formulas
Applications
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Screw Torque Data
Adapter Problems
General Principles

P.A. STURTEVANT CO.
ADDISON, ILLINOIS

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SPACE/AERONAUTICS



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MISSILE GUIDANCE... AIRBORNE RADAR

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Check Employment Inquiry Form on Page 155
198



TRIAL BY FIRE FOR HIGH TEMPERATURE BEARINGS

Part of the bearing development program at Torrington is this "torture chamber" in which jet afterburner and other high temperature operations are simulated.

Here Torrington bearings first met the test of successful operation at temperatures of 800° F. These high temperature bearings are today being produced by the thousands for the aircraft industry.

Meanwhile, Torrington continues to cooperate with

industry in testing new bearing designs and materials at 1000° F, 1200° F and beyond. On the basis of experience and working knowledge already gained, we are confident of developing bearings that will perform successfully at these elevated temperatures.

Developments in high temperature bearings are only one part of Torrington's continuing effort to improve bearings in design, material and performance.

THE TORRINGTON COMPANY

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RESEARCH FOR PROGRESS IN BEARING DESIGN AND PERFORMANCE

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SOLAR T-41M-9

STRATOS DIVISION-FAIRCHILD ENGINE & AIRPLANE CORP. GEA 120-1



AMERICAN AIR FILTER CO. DEFENSE PRODUCTS DIVISION C-10

C. G. HOKANSON COMPANY MODEL 798



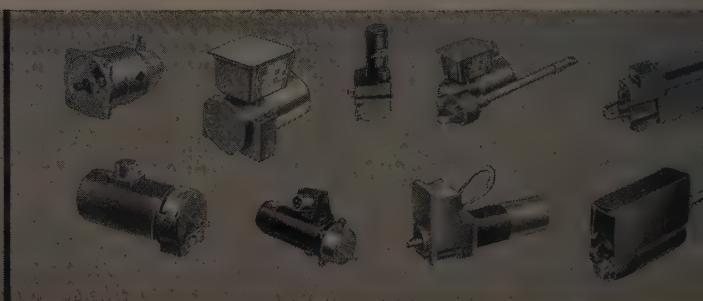
THE MARK OF QUALITY



Aircraft and



AIR VALVES — A wide variety of electrically and pneumatically operated air valves for temperature and pressure-control applications. Butterfly, check, poppet, slide, and automatic drain types.



ACTUATORS — Rotary and linear types featuring a wide range of gear switching and mounting details. Available either as standard units or special to fit various applications. Designed to applicable military specifications.

Barber-Colman ground support temperature controls chosen by leading makers of ground carts and auxiliary power units

Today's highly advanced air and space vehicles call for an ever-increasing array of support equipment — either as preflight air conditioning units or in-flight auxiliary power sources. On many of these, such as shown here, Barber-Colman temperature control systems are employed.

For these systems, components such as control boxes, actuators, valves, temperature sensing elements, thermostats — are furnished by Barber-Colman Company.

The systems are specifically engineered for each application by engineers of the unit manufacturer and Barber-Colman.

Typical functions of Barber-Colman controls in ground support units include controlling temperature of missile guidance compartments and shrouds . . . controlling temperature of missile measurements compartments . . . controlling preflight cabin temperature of jet tankers . . . and many similar precision applications.

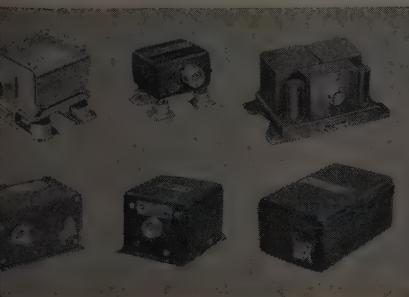
For help on your ground support control projects, consult the Barber-Colman engineering sales office nearest you: Los Angeles, Seattle, Ft. Worth, New York, Boston, Baltimore, Rockford, Montreal.

BARBER-COLMAN COMPANY

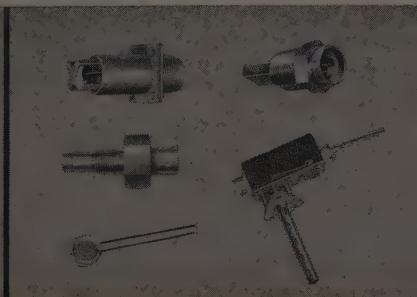
Dept. Q, 1423 Rock St., Rockford, Illinois

Aircraft Controls • Electrical Components • Small Motors • Automatic Controls • Industrial Instruments • Air Distribution Products • Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

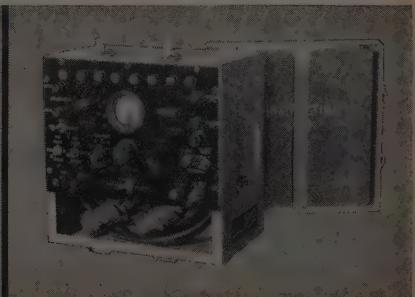
Missile Accessories



TEMPERATURE CONTROL AND POSITIONING SYSTEMS — Electronic, magnetic amplifier, transistor, or relay-controlled systems designed to meet your requirements.



TRANSDUCERS AND THERMOSTATS — Units for sensing compartment, duct, windshield temperatures. CEDAC system senses, controls temperature and/or airflow in ducts.



TEST EQUIPMENT — Compact electrical test units for quickly checking all components of a Barber-Colman control system installed in an aircraft. Special units for checking many electrical systems.

Write in No. 32 on Reader Service Card at start of Product Preview Section

USE THIS NEW KIND OF DIAMOND CUT-OFF WHEEL

Gives narrower, smoother cuts on
industry's toughest materials

...yet prices start at only \$32.25

Now...at production prices...DIATRONIC gives you a rim width of .006" that's accurate to a maximum total tolerance of .0005"—or your money back. This accuracy is built in by a new process. No break-in needed. New narrow cut reduces sawdust loss 30%. A must for \$3,000-a-pound silicon or germanium crystal. Cuts tungsten carbide, corundum, aluminum oxide, glass...practically anything. Stock orders shipped in hours; special wheels available. Write for literature, price list.

*Another invention marketed by
NAVAN PRODUCTS, INC.*

Subsidiary of North American Aviation, Inc.

Dept. 172, International Airport, Los Angeles 45, Cal.

DIATRONIC* DIAMOND WHEELS
"with built-in tolerance" *TRADEMARK

PRODUCT PREVIEW

CHECK VALVE for acceleration forces

This open valve which is sensitive only to acceleration forces, will close between one and three g within .15 sec, according to Aero Supply Mfg. Co., Inc., Dept. S/A, Corry, Pa. The device prevents tank pressure build-up during catapult take-off or, slightly modified, can prevent pressure buildup during arrested landings.

The check valve is said to eliminate the need for multiple tanks and attendant valves and pumps in many applications. It is adaptable for horizontal or vertical installation, with sensitivity to either vertical or horizontal acceleration. It is 5x4½x3 in. wide and it weighs .65 lb.

Write in No. 105 on Reader Service Card

PLATE NUT solves replacement problem

A unique plate-nut assembly that has a replaceable element containing the thread makes plate-nut changing a simple, almost effortless procedure, according to Nutt-Shel Co., Dept. S/A, 811 Airway, Glendale 1, Calif. The Timesaver nut and shell unit eliminates the need for conventional replacement operations such as drilling, nut relocation and riveting.

The nut has two lugs, which hold it in its retainer shell. Removal is accomplished with a small, pry-type tool and replacement requires the aid of a screw driver for the proper snap-in procedure. The entire operation is said to take only five sec. The nut, which is particularly useful for the more inaccessible areas, does not sacrifice performance, weight or function, and cost compares with conventional units. Nine types of the self-locking nut are made.

Write in No. 106 on Reader Service Card
more on page 206

Taber

**TELEFLIGHT®
NEW MODEL 180
AIRBORNE PRESSURE TRANSDUCER**

One of the first and most satisfactory of all Pressure Transducers, the Taber Teleflight has now been reengineered to a weight of LESS than 10 ozs. Its BONDED STRAIN GAGE construction makes it almost completely insensitive to vibration and shock. Its INFINITE RESOLUTION makes possible measurement of feather-light pressures. Can be used with Taber Indicator (shown below) or standard recorders and controllers to measure liquid or gaseous pressures. Handles extremely corrosive media, including fuming NITRIC ACID. Pressure ranges: 0 - 750 or 0 - 1,000 PSIA or PSIG with overload of 100%, Linearity 0.3%, Hysteresis 0.25% of F.S. at any given point, Ambient Temperature -65° F. to +250° F. (18° C to 121° C).

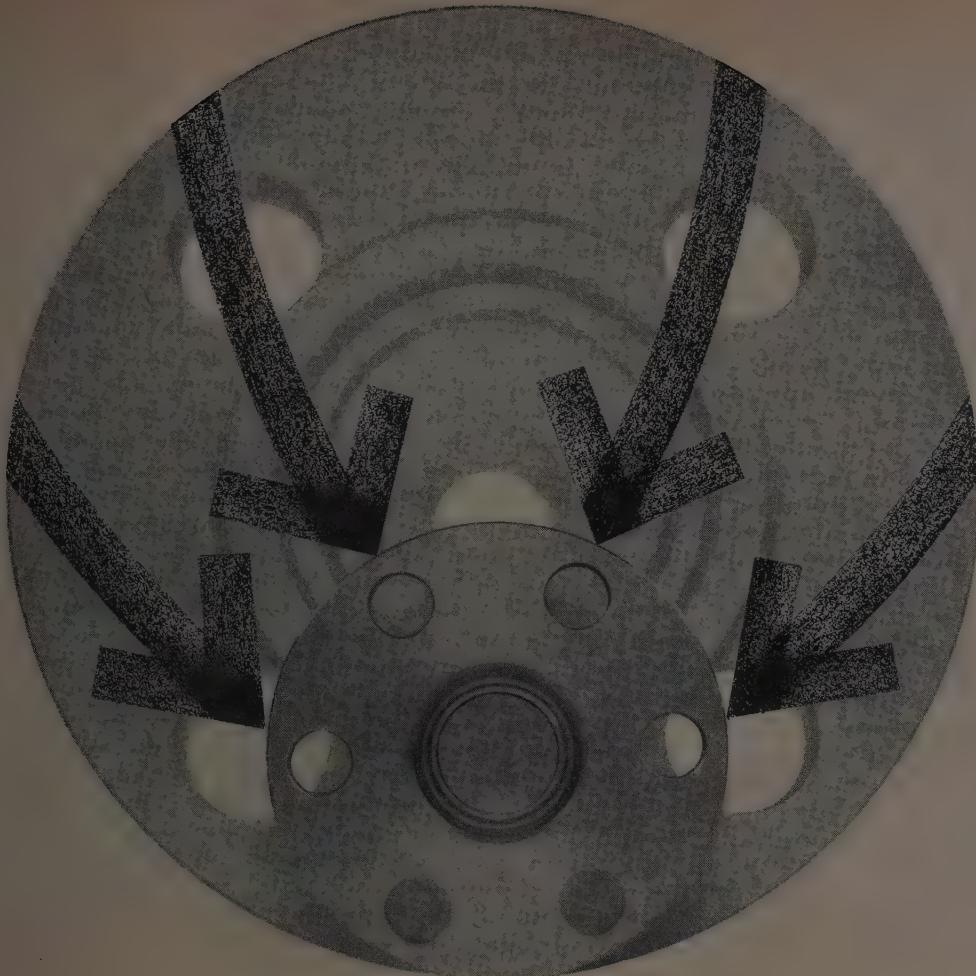
For ground testing, the Teledyne Models 176, 206 and 217 with pressure ranges from 0 - 100 up to 0 - 10,000 PSIG have long been favored by rocket and missile men.

WRITE FOR LITERATURE

TABER INSTRUMENT CORPORATION
Section 36 107 Goundry St., North Tonawanda, N. Y.
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SPACE/AERONAUTICS



WE SHRUNK EVERYTHING...EXCEPT PERFORMANCE

Now you can save up to 50% in piping costs in high-pressure applications—with this new smaller and lighter flange

Now, for the first time, the long-standing problem of how to fit heavy and bulky flanges into the complex configurations of today's high-pressure piping systems has been solved. Equally important, this new stainless steel flange by Accessory Products actually handles pressures *equivalent* to those being handled by standard ASA flanges...*at a tremendous saving in cost!*

Available in line sizes from 1/4 inch through 2 inches, priced from \$30 to \$65—your choice of weld-neck, male pipe thread special high-pressure male adapters, and blind flanges. These flanges provide the ultimate in low-cost, compact, and reliable connectors for all high-pressure piping applications. For the complete story and specifications to meet your piping needs, write for Design Bulletin DB-159. Our engineers will be happy to discuss your specific applications.

APCO ACCESSORY PRODUCTS CORPORATION

a division of textron corporation / 618 West Whittier Blvd., Whittier, Calif. Phone: Oxford 3-3747

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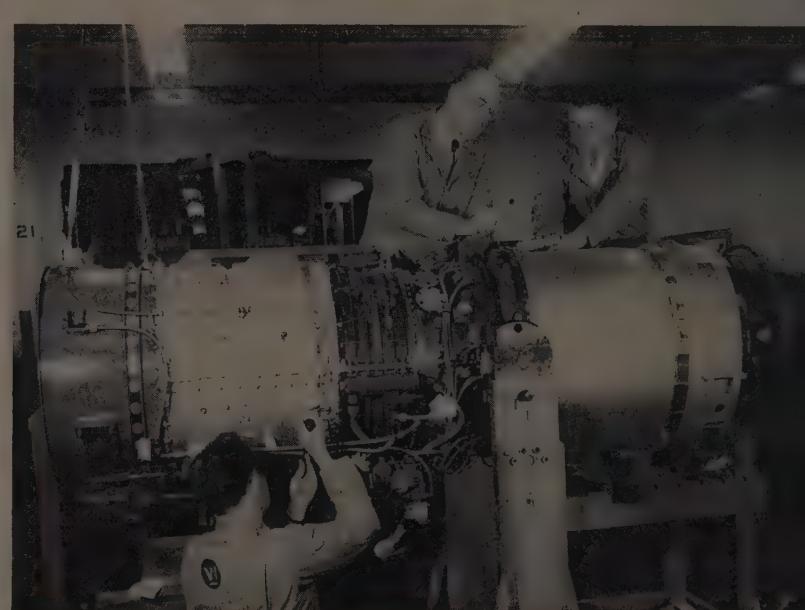
10,904 graduate engineers and scientists with over 133,000 years of experience perform vital tasks at Westinghouse



MISSILE GUIDANCE SYSTEMS. Both ground guidance and terminal guidance systems are designed, developed and produced at Westinghouse. More advanced guidance systems are now being developed to replace those in production and in actual operation. The latest techniques in radar, infrared, and data processing and display are being applied to all phases of missile guidance by Westinghouse engineers with many years of experience in this field. Air Arm and Electronics Divisions



BORNE ELECTRONIC SYSTEMS for weapons control, terrain avoidance, bombing and navigation, antisubmarine warfare, missile guidance, bomber defense and other applications are designed and manufactured by Westinghouse. The 13 Armament Control System, shown above, for the Navy's F4D Douglas Skyray fleet interceptor, is a recent example. Air Arm Division



PROPELLION. From the design of America's first turbojet engine in 1941—by 14 pioneering engineers at Westinghouse—to present-day engines for high-speed aircraft, Westinghouse has kept pace with the aviation industry's constant demand for increases in engine power and efficiency. Current applications include the use of new metals and advanced design features to attain maximum thrust-to-weight ratios, higher speed and higher altitude performance. Jet propulsion engineering reached a new high when the recently developed Westinghouse engine met design goals just 11 1/2 months after these goals were set. Aviation Gas Turbine Division

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EXPERIENCED FIELD ENGINEERS are an important adjunct to Westinghouse engineering capability. Located at key locations abroad, in this country, and afloat—wherever Westinghouse equipment is in use—these field engineers supply experience and information needed to fully evaluate new equipment, help indoctrinate new personnel, and provide technical liaison with the manufacturing plants of the Defense Products



MAN ENGINEERING—uniting man and the machine—is important in electronic equipment design. Continuing scientific study and research at Westinghouse facilitate advantageous application of this concept—from missile analysis to aircraft performance design—in developing better electronic systems. *Air Arm Division*



UNDERWATER IRBM LAUNCHER for the submarine-based Polaris missile, shown here during a test launching with dummy missile, was designed and built by Westinghouse. Design features developed for this system appear applicable for use in other solid-fueled missile



AIRCRAFT ELECTRICAL SYSTEMS. From Jenny to jet, Westinghouse has been producing aircraft electrical equipment representing the day's most advanced state-of-the-art. Systems for today's finest aircraft—including the Boeing 707 jetliner, Convair B-58 bomber, and North American A3J-1 twin-jet fighter—are Westinghouse designed and developed. These systems include the entire a-c power system, control and protective devices, and feature the world's first brushless generator . . . result of pioneering experience dating back to the first airborne, strut-mounted a-c generator built by Westinghouse in 1917. *Aircraft Equipment Department*



NUCLEAR ENGINEERING experience is still exceedingly uncommon, but Westinghouse probably has more knowledge in this very specialized area than any other company in the world. Westinghouse has designed and developed more nuclear power reactors than anyone else. Its engineers have worked in almost every field related to atomic energy. Five different commercial reactor designs are now under active development.



UNDERWATER WEAPONS SYSTEMS. Westinghouse engineers designed the Navy's first all-electric torpedo in 1942. Since then, Westinghouse engineers have continued work on new and improved underwater systems, to include high resolution sonar and a high speed, long range anti-submarine torpedo. Technologies involved include hydrodynamics, acoustic systems, servo mechanisms, and guidance control. *Ordnance Department*

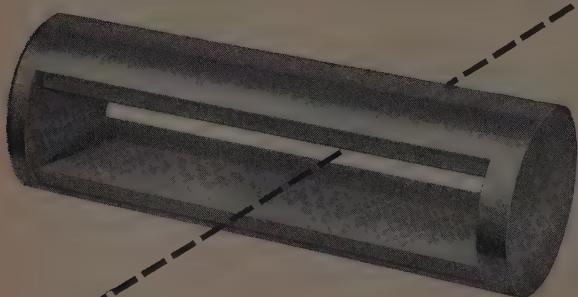
Westinghouse

DEFENSE PRODUCTS
1000 CONNECTICUT AVENUE, N.W., WASHINGTON 6, D.C.

AIR ARM DIVISION
AVIATION GAS TURBINE DIVISION
ELECTRONICS DIVISION
AIRCRAFT EQUIPMENT DEPARTMENT
ORDNANCE DEPARTMENT

YOU CAN BE SURE . . . IF IT'S Westinghouse

What Does a Slide Pin Have to Do With the Cost of VACUUM?



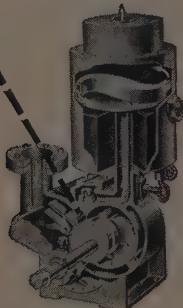
A rotary piston mechanical pump must have a slide pin! And, there's a dramatic difference in the cost picture between a precision-built, one-piece KINNEY slide pin and one that doesn't possess the same engineering niceties. The performance record of KINNEY High Vacuum Pumps in production service accents the big savings in wear, maintenance and downtime of KINNEY one-piece slide pin design. Anything less than superior engineering, quality materials and true craftsmanship just does not belong in a critical part of a Vacuum Pump. You do not risk this gamble when you buy

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HIGH VACUUM PUMPS

KINNEY — the top name in High Vacuum — offers the broadest selection of Single-Stage, Two-Stage and Mechanical Booster Pumps in the world with free air displacements from 2 to 5100 cfm. Single-Stage Pumps developing pressures of 10 microns* . . . Compound Pumps developing pressures of 0.2 micron* and Two-Stage Mechanical Booster Pumps developing pressures to 0.1 micron*.

*McLeod Gage



In addition to the famous Kinney Line of High Vacuum Pumps, Kinney also offers advanced design High Vacuum components and complete systems.

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Company _____
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PRODUCT PREVIEW

SMALL ROTARY SWITCH rated at 5 amp

Designated as M series, this 1 1/8 in dia switch can be easily adapted to a rotary solenoid for use as a stepping or latching relay. Rated at 5 amps, 208 V dc, 400 cycle the switch provides 8 positions. It can be built up to 6 wafers giving a total of 48 separate circuits. A two wafer switch weighs only 8 oz says Mason Elec. Corp., Dept S/A, 3839 Verdigo Rd., Los Angeles 65, Calif.

The unit will withstand 2 to 2000 cps at an acceleration up to 60 G's. Contact resistance averages 0.0005 ohms. Switch is explosion-proof under MIL standards, procedure 2.

Write in No. 107 on Reader Service Card

TEST CART for missile checkout

The Model 9440 hydraulic test cart contributes to missile checkout by simulating the hydraulic power package normally used in the missile. The device delivers ten gpm of oil at pressures up to 3000 psi, and automatic back pressure is provided to within plus or minus one psi, according to George L. Nankervis Co., Dept. S/A, 15300 Fullerton Ave., Detroit 27, Mich. Included in the test cart, which is powered by a 15-hp motor, is ten-micron filter equipment for initial flushing of the system components to remove foreign matter. The test cart is mounted on casters.

Write in No. 108 on Reader Service Card

AMPLIFIER KLYSTRON is six-cavity water-cooled

This new six-cavity water-cooled amplifier klystron, the 6K50,000LQ, for use in the 720 to 980 megacycle range, delivers ten KW CE power output at ten megacycle bandwidth with a driving power of only five watts and an efficiency of 40 percent. At 25 per cent efficiency it is effective over a 20 megacycle bandwidth, says Eitel-McCullough, Inc., Dept. S/A, San Bueno, Calif.

This equipment now spans the gap between Florida and Cuba, transmitting TV programs simultaneously with multi-channel telephone service.

Write in No. 109 on Reader Service Card

FERRITE ISOLATORS for test equipment

This series of extremely broad frequency band ferrite isolators designed to meet the exceptionally high characteristics required for test equipment applications is available in WR-28, WR-42, WR-62, WR-90, WR-112, WR-137, WR-187, WR-284 waveguide sizes, says Airton, Inc., Dept. S/A, 1096 W. Elizabeth Ave., Linden, N.J.

These ferrite isolators provide optimum frequency stability of test equipment and measurements during test, and extend the life of the RF source by giving a high degree of isolation between the RF source and the microwave component under test.

Write in No. 110 on Reader Service Card

TRANSFORMERS for preferred circuits

This kit of ten Pulsite transformers will facilitate the design of blocking oscillators, says Airpax Products Co., Dept. S/A, Middle River, Baltimore 20, Md. Included are eight oscillator units with turns ratios of 1:1:1 and open-circuit primary inductances from 0.08 to 158 mh, and two interstage units with a 5:1 turns ratio.

The units plug into seven-pin miniature tube sockets. They are hermetically sealed, will operate from -55 to +105 deg C, and have a power rating of two W. They can be used in pulse circuits for impedance matching or phase inversion, or in linear audio-frequency oscillators.

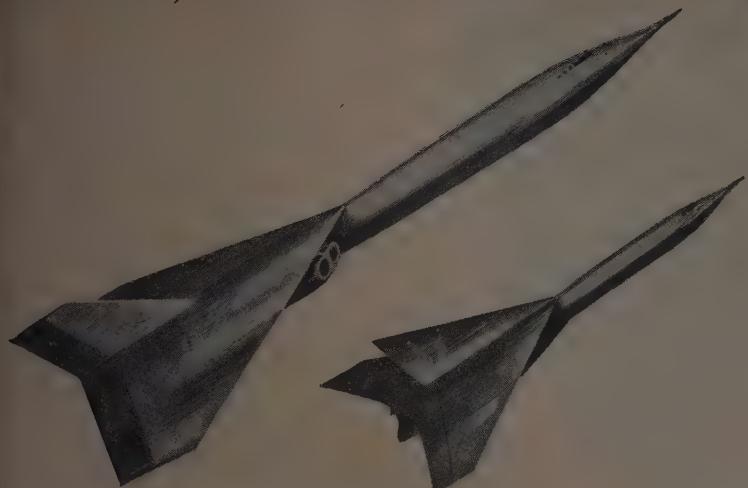
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more on page 209

SPACE/AERONAUTICS

ARMCO STEELS for Aircraft and Missiles

New steels are
born at
Armco



ARMCO PRECIPITATION-HARDENING STAINLESS STEELS . . .

**Used in Today's Aircraft--
Planned for Tomorrow's**

Armco's high strength-weight ratio stainless steels, PH 15-7 Mo, 17-7 PH and 17-4 PH, are widely used in our newest missiles, fighters, and bombers, and in *all* the new jet-powered commercial airliners.

They are specified for airframe structures and skins, pod assemblies, engine parts, accessories and instruments because they have a unique combination of properties—light-weight strength at temperatures to 900-1000 F, good corrosion resistance, and excellent fabricating characteristics that assure economical producibility.

These properties have given designers new opportunities to create reliable components that withstand the heat and stresses of jet-propelled flight . . . and save weight.

Tomorrow's aircraft now on drawing boards, will utilize the many advantages offered by these special Armco Stainless Steels to solve some of the complex problems imposed by speeds of Mach 2 and beyond.

Consider the design and production possibilities of Armco Precipitation-Hardening Stainless Steels for the units *you* are making or designing. Mail the coupon for complete information on their properties and fabrication.

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MOMENT IN HISTORY

THIS IS THE "FIRST FLIGHT"

of the new Air Force TITAN

America's most powerful weapon and
our No. 1 challenger in the big-missile
field. Time: 2/6/59—4:22 p.m. EST.

The most important thing about
this moment in history is not
visible here—and it is this:

Three years to the
day from the breaking of ground
at Martin-Denver, TITAN No. 1 roared
into the sky. Those 36 months
saw the creation of the free world's
most advanced ballistic missile
facility—and the development,
production, testing, delivery and
launching of the first of an entirely
new generation of ballistic
missile weapon systems, forerunner
of the Global Ballistic Missile.

TITAN is the
result of an advanced engineering
concept—developed by Martin under
the direction of the Air Force's
Ballistic Missile Division
of the Air Research and Development
Command—which provides the
most extensive pre-flight testing of
components, subassemblies and full
scale missiles ever undertaken.

This method in
the TITAN development,
and in the generations of space
systems to follow, may well
be one of the most important single
factors in speeding America's
bid for space supremacy.

TIME DELAY RELAYS
for military use



Martin-Denver

is one of the

seven divisions

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MARTIN
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These H series thermal time delay relays are designed for airborne, computer, missile, and other military applications to operate under vibration from zero to 500 cps at ten g and shock up to 50 g. Factory preset from three seconds to three minutes, the hermetically sealed relay will operate at altitudes to 70,000 ft. Ambient temperature compensated from -65 to 125 deg C, says Curtiss-Wright Corp., Dept. S/A, Wood-Ridge, N.J.

The single pole single throw normally open or normally closed contacts are rated at three amperes 120 volts ac or two amperes 32V dc resistive loads.

Write in No. 112 on Reader Service Card

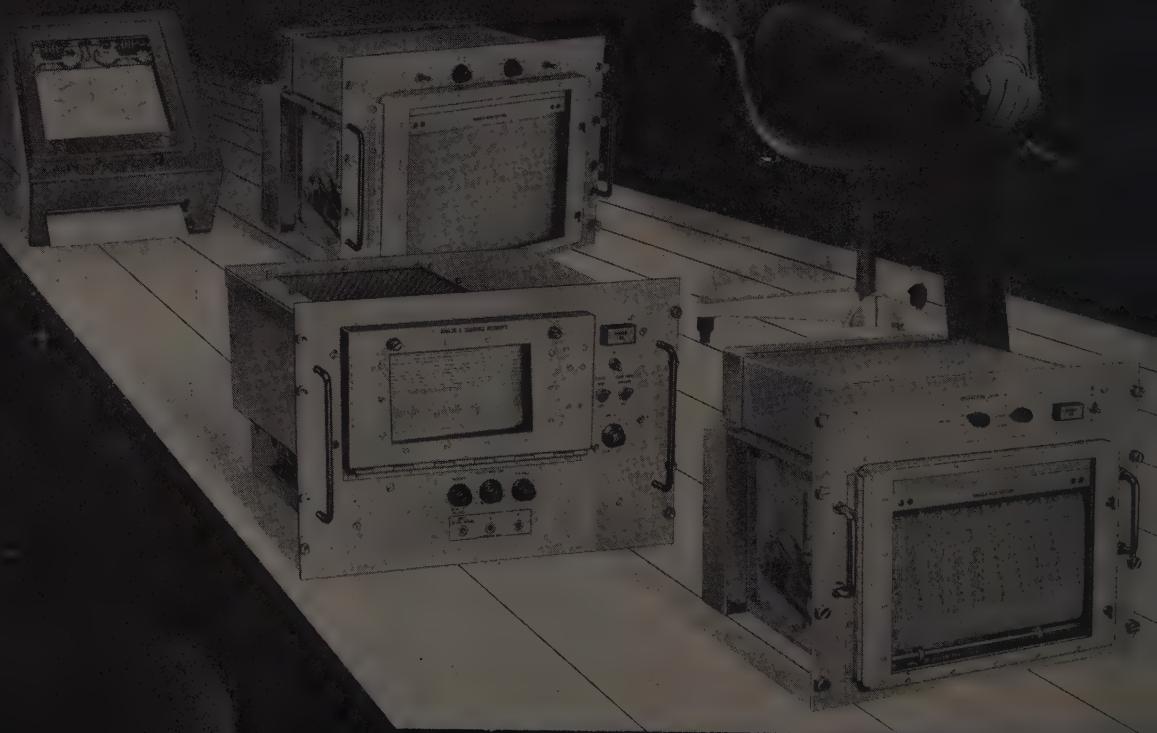
ADHESIVES
bond Teflon

Ray-BOND R-86009 and Ray-BOND R-86044 are new adhesives that will bond etched Teflon to itself or to wood, steel, glass, aluminum, ceramics, plastics, or any other material that will bond with an adhesive, says Raybestos-Manhattan, Inc., Dept. S/A, Bridgeport 2, Conn. Ray-BOND R-86009, which offers some flexibility in the bond, can be used as a structural adhesive at temperatures up to 120 deg F and as a non-structural adhesive up to 250 deg F.

It has good resistance to water and most chemicals. Ray-BOND R-86044, which has excellent resistance to acids (except acetic), as well as other chemicals, has a 200-deg F limit for structural use and 250 deg for non-structural. The adhesives consist of base and activator, and they may be cured at room or elevated temperatures.

Write in No. 113 on Reader Service Card
more on page 212

Brush militarized recording



systems are

READY NOW FOR "2nd GENERATION" SPACE VEHICLES!

When "second generation" space vehicles become operational, the readout of their performance will be monitored by Brush militarized equipment already in existence.

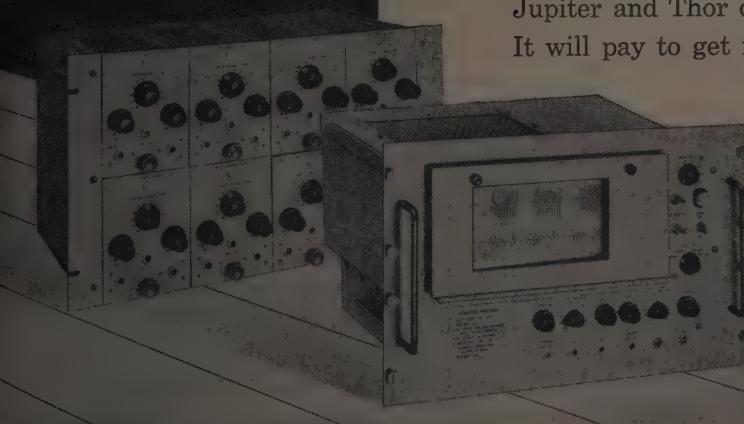
For instance, the 100-Channel Operations Monitor that will record 100 channels of data simultaneously — on a chart 12" wide! Complex checkouts are simplified.

Or 2- and 6-channel systems (including oscillograph and amplifier) . . . or the combination Analog and Sequential Recorder.

All equipment complies with Mil. E-16400, Mil. E-4158, Mil. E-4970 and other specifications as required.

For maximum reliability, equipment utilizes fast-response electric writing, proven on critical operational sites such as DEW Line, Jupiter and Thor checkouts.

It will pay to get familiar with this equipment now — before you are confronted with prototype design problems. Brush engineers are available to give you needed details, or write us direct.



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CORPORATION

CLEVELAND 14, OHIO

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McGILL CAMROL and GUIDEROL bearings



...add dependability
to ground
support equipment

High capacity in limited space plus precision accuracy make these bearings ideal for use as track, guide and support rollers in missile and rocket ground support equipment.

CF SERIES CAMROL bearings feature an integral stud and heavy duty outer race. They eliminate the cost of building up improvised bolt and roller units and withstand the shock of heavy loading. Also available with seals and pre-lubricated.

GR SERIES GUIDEROL bearings provide full complement roller capacity with self-guided rollers for true-running trouble-free performance. SG SERIES sealed GUIDEROL bearings are also available for applications where contamination must be sealed out and lubrication sealed in.

For data on the complete line of McGill Bearings, send for Catalog No. 52A



engineered electrical products

McGILL
precision needle roller bearings

McGILL MFG. CO., INC., Bearing Division
621 N. Lafayette St., Valparaiso, Indiana

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212

PRODUCT PREVIEW

SOLENOID is oil-cooled

A valve expected to have 20 to 30 times the useful life of regular solenoids is an improved version of the two- and four-way hydraulic directional valves used in missile handling systems, says Vickers, Inc., Dept. S/A, 172 E. Aurora St., Waterbury 20, Conn. Internal temperatures remain at low levels even during heavy-duty continuous and rapid operations, because the coils are immersed in oil.

The solenoid is available in seven spool types, with a flow range of from 1.25 to 320 gpm and operating pressures to 3000 psi.

Write in No. 114 on Reader Service Card

INERTIA SWITCHES have long life



Single-pole, double- or triple-throw miniature inertia switches that can be actuated by acceleration, deceleration, impact, and shock are being made by Inertia Switch Div., Safe Lighting, Inc., Dept. S/A, 527 Lexington Ave., New York 17, N.Y. Acceleration sensitivity is adjustable from under one to over 100 G with an accuracy of one per cent.

Available contact arrangements include momentary, latching with mechanical reset, latching with electric reset, and latching with negative G reset; electric power is required only for electrical reset. The normally closed switch will open in under one msec and is guaranteed for 10,000 reliable cycles of operation. Weight is 1.75 oz; standard length is 1.698 in.

Write in No. 115 on Reader Service Card

FILTER ELEMENT is replacement unit

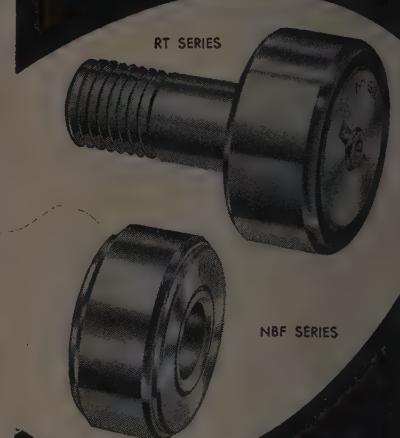
A Micropleat-type filter element has been designed as a replacement for existing designs of main fuel line filters on aircraft such as DC-4, 6 and 7 models, says Bendix Filter Div., Bendix Aviation Corp., Dept. S/A, 484 W. 12 Mile Rd., Madison Heights, Mich. The element has a ten-micron rating.

The filter materials is supported by corrosion resistant metal end caps, which are gasketed to assure a tight seal, and a perforated metal core. The element is 3 1/2 in. in dia. and 6 1/8 in. long. Pressure differential ranges from about 0.01 psi at two-gpm flow to 0.8 psi at 10-gpm flow.

Write in No. 116 on Reader Service Card

more on page 214

McGILL Aircraft needle bearings



...insure performance
under aircraft
specifications

Full complement needle bearing capacity, precision accuracy to NAS and AFBMA standards, non-separable construction, lightweight and high material selection standards qualify MCGILL RT, NBF, NBL and NBC bearings for aircraft cam, track, and guide roller applications. Surfaces plated as required.

RT and HRT SERIES—for use when a cantilever type stud mounting is required. Plating or surface treatment and lubrication holes supplied as application dictates.

NBF AND NBL SERIES—for use in applications where the bearing O. D. is unsupported and will support rolling loads in cam or track support.

NBC SERIES—for applications where bearing O. D. can be supported in a housing. Suitable for slow rotation and oscillation.

Consult our Engineering Department for Special Aircraft bearings built to specification —

Write for free
Workbook Guide
to Series and sizes



engineered electrical products

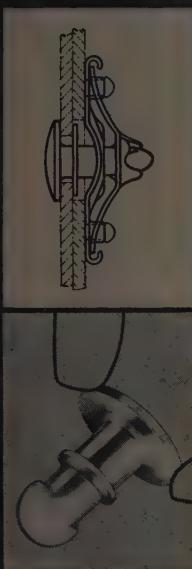
McGILL
precision needle roller bearings

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SPACE/AERONAUTICS

Criteria of Reliability . . .



BOEING 707 Jet Stratoliners

use LION Quarter-turn FASTENERS

The demands of today's airborne requirements are met by Lion Quarter-turn Fasteners. They are accepted as

standard throughout the aircraft industry. They are completely reliable . . . stand up under the most rugged conditions of shear, vibration and tension.

Smooth positive action is assured by the swaged-nose stud on Lion Quarter-turn Fasteners. There are no milled sections, inserts or cross pins; no potential points of failure. No wire spring is required to hold the Fastener in locked position.

One-quarter turn locks the Fastener . . . one-quarter turn opens it. Six head styles and two sizes available. Lion Aviation Fasteners meet MIL-F-5591A (ASG) requirements and are CAA approved.

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LION Aviation FASTENERS

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MILITARY



COMMERCIAL

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Thermal stability

Low noise

reliability



BRISTOL'S

low-noise, low-thermal Syncroverter* choppers

In solving the above equation, Bristol has paved the way for new advances in low level switching. New performance standards are being established by these latest models of the external coil Syncroverter chopper.

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*T. M. Reg. U. S. Pat. Off.

BRISTOL

FINE PRÉCISION INSTRUMENTS
FOR SEVENTY YEARS

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PRODUCT PREVIEW

ENCODER is all-electronic

The Avion Type 525 Encoder is an all-electronic conversion of analog input data to digital output voltages. Particular emphasis is placed upon accuracy and resolution, says Avion Div., ACF Industries, Inc., Dept. S/A, 11 Park Place, Paramus, N.J.

The encoder is said to make possible the use of versatile noise-free digital transmission and computing techniques to a greater degree of accuracy than heretofore possible. When used in combination with an Avion decoder, it becomes possible to solve problems in telemetering, analog computation, digital computation, PCM, and many other data processing applications.

Write in No. 117 on Reader Service Card

SYNCHRO TRANSMITTERS are linear

These components, dimensionally identical to Type R 900 Series synchros, are highly linear induction potentiometers which provide accurate linear indication of shaft rotation, says Kearfott Co., Inc., Dept. S/A, 1378 Main Ave., Clifton, N.J.

The indication is about a reference position in the form of a polarized voltage whose magnitude is proportional to angular displacement. Because they are induction type devices, no sliders are needed to make electrical contact. Accuracy is maintained at the original level throughout the operational life and outputs of shaft rotation are linear over a range of ± 6 deg from electrical zero. The units may be furnished with either terminals or leads, and with special shaft configurations.

Write in No. 118 on Reader Service Card

SANDWICH CORE is very strong

A honeycomb sandwich core structural material for aircraft and missiles, called Conocomb, has an extremely high strength-weight ratio, along with high rigidity, excellent insulating properties, superior durability, and high resistance to fire, says Flexible Packaging Div., Continental Can Co., Dept. S/A, Mount Veron, O. There are three types of Conocomb—fiberglass, kraft paper, and asbestos, and they have been used in airplane furnishings, interior walls, wings, radomes, missile fins, engine shelters, and other applications.

Fiberglass Conocomb is available in polyester, Nylon phenolic, and high-temperature phenolic types, and in three cell sizes. The kraft type comes expanded or unexpanded, impregnated or unimpregnated and it may be obtained in varying cell sizes and weights.

Write in No. 119 on Reader Service Card

POTENTIOMETER is sub-miniature

Model 1410 is a 1 watt, 200 to 25000 ohm potentiometer. The shaft, front bushing and bearing are manufactured from corrosion resistant Nickel Silver. The unit will withstand accelerations up to 50 G's in three planes without electrical or mechanical damage and without wiper deviation from a set mechanical angle says S. A. Asquith Co., Dept. S/A, 427 W. Chevy Chase Drive, Glendale 4, Calif.

Wiping contacts are made from noble metal laminates. Bearings are provided front and rear and the shaft and wiper are electrically isolated. The stop mechanism is associated only with the shaft, permitting rotational accuracy. Stop strength is better than 8 in.-lbs. The unit will meet specifications JAN-R-19, JAN-P-18, JAN-P-79, JAN-R-382, and MIL-E-5400.

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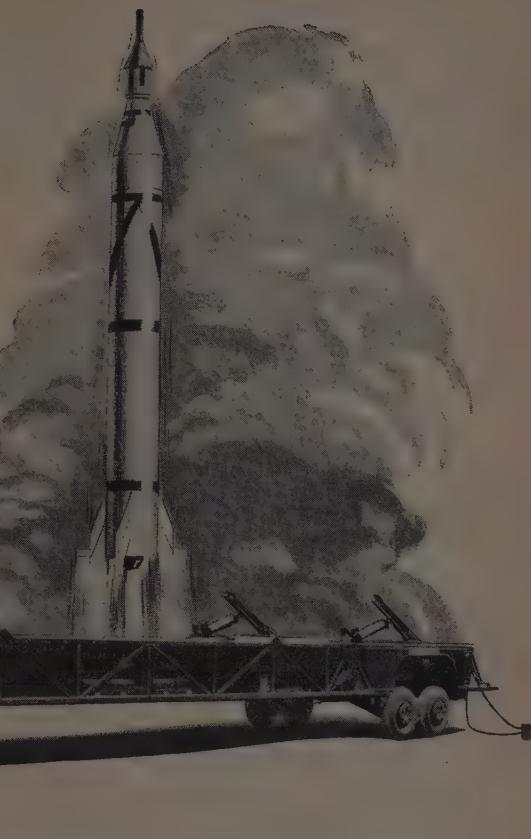
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SPACE/AERONAUTICS

If It's A Military Ground Handling Problem, Fruehauf Can Handle It!

Experience and facilities are both at your command when you enlist Fruehauf's assistance in the ground handling portion of your military equipment contract.

Fruehauf's unparalleled experience has been gained over a number of years on an almost staggering number and variety of ground handling projects. These include research, design, and production of containers or transporters for many types of missiles . . . of numerous missile launchers . . . missile guidance shelters . . . shelters for radar and electronic equipment . . . specialized tank-trailers for military fuels . . . powder haul vans . . . mobile containers for materials and supplies . . . and over 400 different types of other military vehicles.



Fruehauf's unexcelled facilities include modern, diversified manufacturing plants all across the nation, with automated production lines and some of the most modern precision machinery to be found anywhere in the country today. Facilities also include extensive research and engineering staffs totally devoted to collaboration on ground handling designs and projects with prime contractors everywhere.

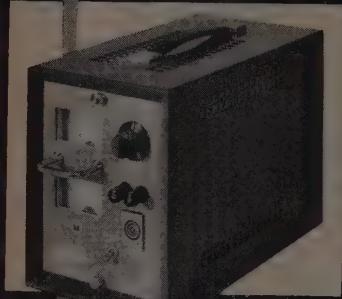
Fruehauf's long history as a leading trailer manufacturer has undoubtedly given impetus to its growth as an important source of ground handling assistance. Whatever the nature of your contract, if it contains a ground handling problem by all means consult Fruehauf.

MILITARY EQUIPMENT DIVISION
FRUEHAUF TRAILER COMPANY

10942 Harper Avenue, Detroit 32 • 5137 South Boyle Avenue, Los Angeles 58

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Absolute ISOLATED DC POWER SOURCE



for

RESISTANCE-TYPE
TRANSDUCERS
STRAIN GAGES
ACCELEROMETERS

Now for the first time you can have the dependability and ease of operation of an electronic power supply *plus* the isolation normally obtained only from a battery. The Moeller Model 21 Power Supply exclusively provides *absolute isolation from line voltage and line ground*.

The Model 21 provides 0-20 volts, 1 amp of power for strain gages and resistance-type transducers. This transistorized instrument gives improved performance with existing single-ended and differential amplifiers and offers voltage regulation, internal impedance, ripple and stability equal to, or superior to, conventional transducer power supplies.

Write for descriptive literature.

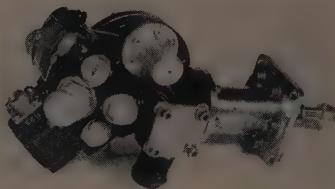


MOELLER
INSTRUMENT CO.
ELECTRONICS DIVISION

132nd Street & 89th Avenue
Richmond Hill 18, N. Y.

PRODUCT PREVIEW

CONTROLLER
corrects thrust pressure

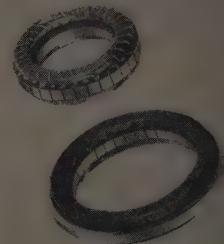


Errors in thrust chamber pressure in liquid propellant rocket engines can be detected and corrected with this new hydromechanical controller, according to Bendix Products Div., Bendix Aviation Corp., Dept. S/A, South Bend 20, Ind. The device operates by producing a rate of change in the position of an actuator, which can be used to govern the flow of propellant to gas generator and of hot gas from generator to turbine.

Other major components of the controller include a two-stage pressure regulator for obtaining an accurate reference and a pneumatic phase-lead device for obtaining a damping signal proportional to the rate of change in thrust chamber pressure. A torque motor permits engine thrust level to change as a function of a remote electric control signal.

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PANCAKE SYNCHROS
are very accurate



These synchros and resolvers, designed for applications—such as inertial guidance systems—where a pancake configuration is necessary, feature accuracies down to five min., says Luther Mfg. Co., Dept. S/A, 7312 Varna St., North Hollywood, Calif. They are available in sizes 20 and 27.

Electric properties can be designed to meet specific applications or to match standard components for accuracy, voltage gradient, and impedances.

Write in No. 122 on Reader Service Card

more on page 219

Reduce Installation Costs of Thermocouple Extensions with



THERMO-CABLE

You can now install 6 to 56 pairs of thermocouple leads at one time with "Thermo-Cable," T-E's new multi-conductor extension cable. Installed in conduit, "Thermo-Cable" reduces costs by eliminating the need to pull individual conductors—and permits the use of smaller conduit for the same number of leads. "Thermo-Cable" can also be installed without conduit, in open troughs or in raceways.

"Thermo-Cable's" smooth, polyvinyl chloride outer jacket resists moisture,

heat, abrasion and chemical action—and slips easily through conduit. ISA color coded, individual conductors are also insulated in hi-temp (221°F.) polyvinyl chloride—and the conductor bundle is wrapped in aluminum-backed Mylar tape for electrostatic shielding. Pairs are numbered alike and lie next to each other. "Thermo-Cable" is available in 6, 14, 18, 25, 39 or 56 pairs and comes in all standard thermocouple materials.

Write For Wire Section 33-A

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SADDLE BROOK, NEW JERSEY

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Brampton, Ont.

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SPACE/AERONAUTICS

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Center—*Dr. Howard Baller*, Director of Engineering. His department gives substance to ideas, showing how these ideas can be converted into practical military and industrial products.

Right—*Kenneth J. Carlson*, Director of Manufacturing, and his men transform theories and designs into physical realities, utilizing the skills of all three departments to meet every production requirement—*on schedule!*

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MECHANICAL DIVISION

1620 Central Avenue, Minneapolis 13, Minnesota

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A rocket's fueling system is its lifeline. That's why Parker Seal Company, a division of Parker-Hannifin Corporation, has chosen KEL-F Brand Halofluorocarbon Elastomer 5500 for the sealing element (arrow) in its Gask-O-Seals to withstand RFNA and WFNA. Parker also provides O-Rings of this material for many types of service.

KEL-F Elastomer's remarkable chemical and thermal stability makes it ideal for use with JP4 and JP5 fuels at temperatures as high as 400°F. It's effective, too, with 90% hydrogen peroxide, from -40°F. to 165°F. And the

Elastomer works wonders with hot lubricants.

Look to KEL-F Brand Plastics, also, to improve your product's design and performance. They exhibit zero moisture absorption, high dimensional stability, virtually no cold flow. They have excellent electrical and mechanical properties as well. Investigate both KEL-F Plastics and Elastomers and these other 3M Chemicals for the aircraft and missiles field: KEL-F Molding Powders, Dispersions and Fluids, Fluorochemical Inert Liquids and other specialty chemicals.

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SPACE/AERONAUTICS



PRODUCT PREVIEW

RECORDER has fast start

A start and stop time of under 30 msec, frequency response to 130 kc, and a four-V rms output into 180 ohms are major features of the Model 707 telemetering-ground station instrumentation tape recorder, says Midwestern Instruments, Dept. S/A, P.O. Box 7186, Tulsa, Okla. The Magnecord units are available in $\frac{1}{2}$ -, $\frac{1}{4}$ -, and one-inch tape models, with two, seven and fourteen tracks, respectively, and in many speeds.

Plug-in modules provide direct analog, PDM and FM recording.

Write in No. 123 on Reader Service Card

VITAL ROLE of KEL-F Plastic in aircraft and missiles applications is represented by these relay coil forms, produced by American Molded Products Co., Chicago, Ill. The combination of characteristics in the Plastic makes these parts more than a match for missiles requirements. The Plastic performs without softening or warping over extreme temperatures, ranging from -320° to $+390^{\circ}$ F. It has exceptional dimensional stability, zero moisture absorption, high dielectric strength. Tough, workable KEL-F Plastic also exhibits remarkable chemical stability.

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May 1959

STATIC INVERTER has no moving parts



Model W-1347 static inverter converts dc to ac without moving parts. The 400-cps output frequency is regulated to ± 1 cycle. Output voltage—nominally 115 V—is regulated to ± 2 per cent says Electrosolid Corp., Dept. S/A, 13745 Saticoy St., Panorama City, Calif.

No special cooling is required. The three-phase static inverter, which contains both germanium and silicon transistors, can be mounted on insulation material in remote spots. Input voltage can vary from zero to 40 V dc. The output circuit will sustain direct short circuits and will recover to full normal operation in 10 milliseconds after short removal. The 100-va unit measures $8\frac{1}{2} \times 7 \times 11\frac{1}{2}$ in. and weighs only seven pounds.

Write in No. 124 on Reader Service Card

CLIP mounts capacitors

Kap-klip is a non-metallic clip designed for mounting Fansteel-type PP, HP, and VP tantalum capacitors on circuit boards. It is available in Nylon and Kel F materials, the former for a range of 50 to $+125$ deg C and the latter for -55 to $+150$ deg C, says Slug Bit Supply Co., Dept. S/A, 9745-A Hines Blvd., Dallas 25, Texas.

The device allows faster and easier assembly of leads, and it insulates 90 per cent of the capacitors from other circuit components. It has held capacitors under a vibration of ± 20 g's, over the frequency range of five to 2000 cps.

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more on next page

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For more information please write to: Mr. P. E. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 45, California.

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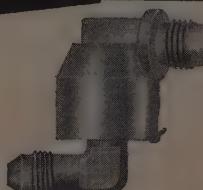
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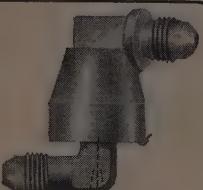
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PRODUCT PREVIEW

TITANIUM in foil gages

Titanium foil that can be used as aircraft honeycomb material is now being produced from commercially pure titanium and some titanium alloys, the latter for the first time, according to Metals & Controls Corp., Dept. S/A, Attleboro, Mass. Profile-rolled "L" shapes have also been produced from the commercially pure.

All types of commercially pure can be rolled to a minimum thickness of .001 in., and Beta alloys, Type B-120 VCA, to .002 in. Alpha-Beta and other alloys can be rolled to a minimum .003 in., depending on the alloy. All types can be annealed.

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SILICON RECTIFIERS rated at 3/4 amp

This series of diffused junction silicon rectifiers have peak inverse voltage ratings ranging from 50 to 600 volts and can deliver 750 ma dc of rectified current at 50 deg C and 250 ma dc at 150 deg C says Bendix Aviation Corp., Red Bank Div., Dept. S/A, Long Branch, N.J.

The EIA designations for this series are IN536, IN537, IN538, IN539, IN540, and IN547.

Write in No. 127 on Reader Service Card

TRANSISTOR is bilateral

The outstanding feature of the transistor, type 2N462, is its bilateral characteristics. Possible applications include complementing circuits, bi-directional switches, bi-directional amplifiers, and phase detectors, says Philco Corp., Dept. S/A, Philadelphia, Pa.

The Philco 2N462 is distinguished by exceptionally high voltage, current, and gain ratings. Maximum collector (or emitter) voltage is 40V; maximum collector (or emitter) current is 200 ma. Dc current amplification factor (β_{dc}) is typically 45, in either direction. Alpha cutoff frequency is 0.5 mc min, with carefully controlled rise and fall time.

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POWER SUPPLY protects circuits

The Model SS-2 Safety Supply a dc power supply for transistor work, protects against overload, current creep, overheating, short circuits and other conditions encountered experimentally, says Western Apparatus Co., Dept. S/A, 2001 Greenleaf St., Evanston, Ill. Overload is restricted to 20 per cent of the selected current, even under short circuit conditions.

The laboratory unit provides voltages of six, 12, 18, 24 and 30 V, with limiting current ranges of one, three, ten and 30 ma. Internal impedance is about ten ohms, and RMS ripple is less than 0.1 per cent.

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SINE SWITCH for high temperatures

A miniature switch designed to operate continuously at temperatures as high as 375 deg F is now available from Spencer Thermostat Div., Metals & Controls Corp., Dept. S/A, Attleboro, Mass. Terminations are either screw or solder type.

The KX5 is a high-capacity type capable of withstanding severe environmental conditions. Sealing is accomplished with the aid of glass and fused ceramic headers. The switching element is the Klixon sine blade. Auxiliary leaf, roller and push button actuators providing additional over travel are available.

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more on page 222

SPACE/AERONAUTICS

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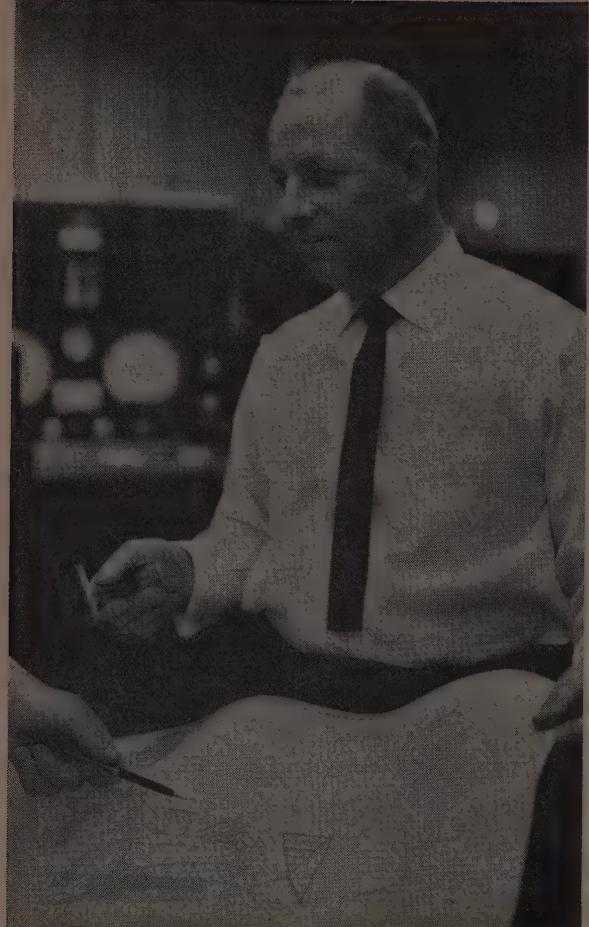
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PRODUCT PREVIEW

MACH SWITCH *in weight-saving design*

A new, force-balance, direct-acting Mach switch uses simplified design and construction to achieve a weight saving of up to two lbs over some current Mach switches, says Burton Mfg. Co., Dept. S/A, Colorado Ave. & 26th St., Santa Monica, Calif. The switch, which was designed for a new highspeed Air Force jet, is about four in. in dia and 1½ in. deep, and it weighs one lb.

The rugged instrument can be made to open or close at selected Mach points up to two Mach. It has an accuracy of +2 per cent and is free from contact flutter under environmental conditions. Altitude range of the device is 70,000 ft.

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INVERTER *for airborne components*

This inverter will supply airborne components with a regulated source of 115/200 V, 400 cycles ac, at a 3500-va load, from 27.5 V dc. Voltage and frequency regulation is obtained by a hermetically-sealed, potted, magnetic amplifier regulator, says Western Design & Mfg. Corp., Dept. S/A, Santa Barbara Airport, Goleta, Calif.

The Model 433 inverter maintains a \pm one per cent excursion on frequency and voltage for any combination of load-temperature-input voltage change over a 50 per cent load variation, a -65 to +165 deg F ambient temperature range, and a \pm 5 per cent input voltage. The inverter weighs 63 lbs and is packaged in a pressure-tight canister. It is also available in ratings ranging from 1500 to 3500 va.

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UHF BEAM POWER TUBE *is forced-air-cooled*

Type RCA-7213 is a forced-air cooled, ultra-high-frequency beam power tube with ceramic-metal seals. Designed for use as a linear radio-frequency power amplifier and as a class C r-f power amplifier, the tube has a maximum plate dissipation rating of 1500 watts throughout the frequency range from 960 to 1215 Mc. says the Radio Corp. of America, Dept. S/A, 30 Rockefeller Plaza, New York 20, N.Y.

When used under continuous-commercial-service (ccs) conditions as an r-f power amplifier in class C telegraphy service, the maximum plate-input rating is 2500 watts. Under these conditions in a grid-drive circuit, the tube can deliver useful power output of 1350 watts with a power gain of 20 at 800 Mc. As a linear power r-f amplifier in a single-sideband suppressed carrier service, the tube can provide a maximum-signal power output (ccs), of 1250 watts.

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FREQUENCY CONVERTER *is 85 per cent efficient*

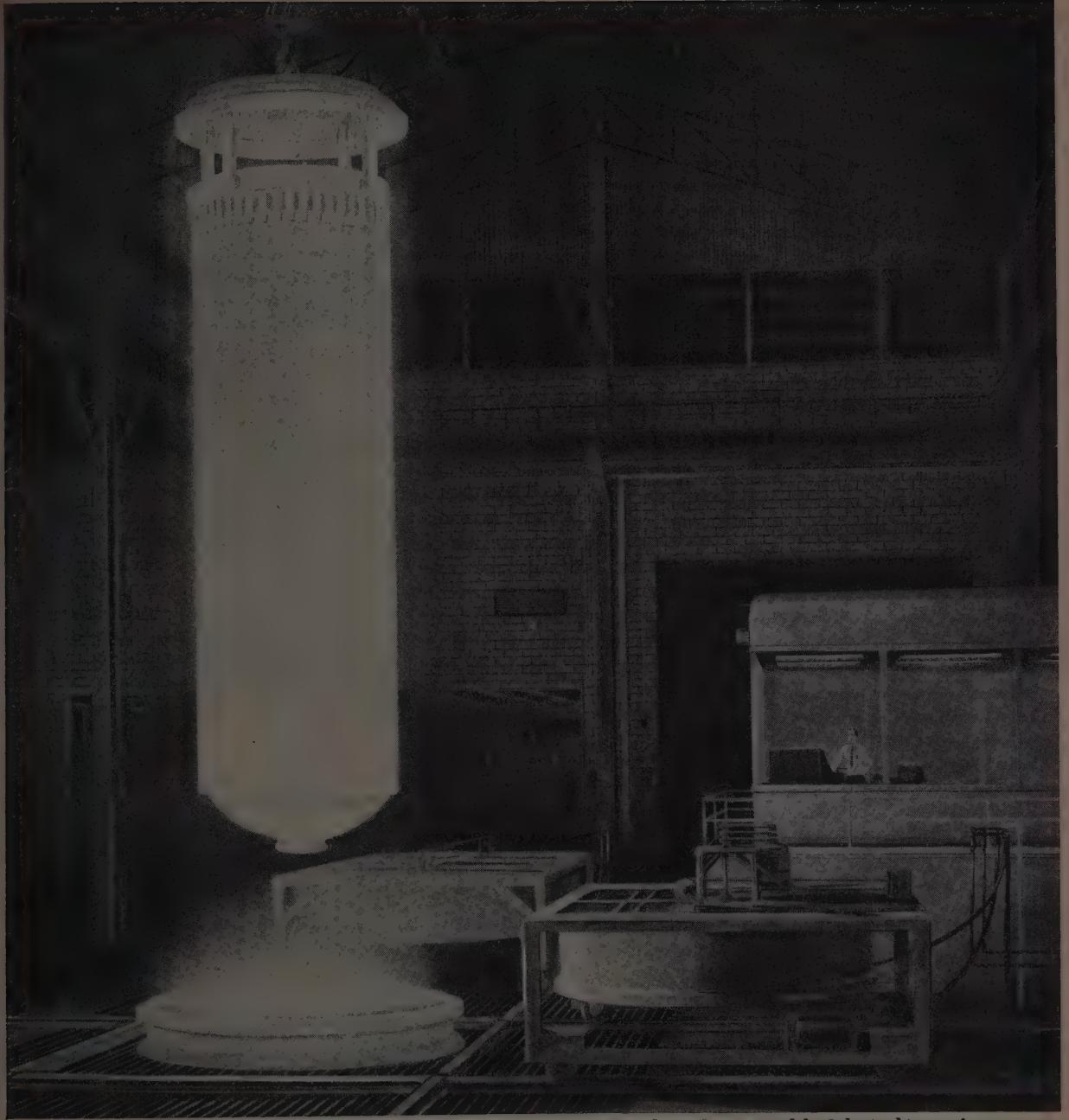
This transistorized Frequency Converter which can be supplied with an output frequency of 1200 or 2400 cps, consists of a synchronized-transistor square-wave generator driving a switching-transistor power output stage. Synchronization of the square-wave generator is accomplished by injection of a 2400 cycle sinewave synchronizing signal across the base resistors of the generator. Synchronizing power is obtained by frequency multiplication of the 400 cycle three phase input. It has an input of 95 W and an output of 75 W, says Robertshaw-Fulton Controls Co., Dept. S/A, 401 N. Manchester, Anaheim, Calif.

Low weight and high efficiency of the frequency converter are said to make it ideal for airborne use. Weighing about 2 lbs, fully loaded, efficiency is claimed above 85 per cent.

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more on page 224

SPACE/AERONAUTICS



Giant missile components—including rocket motors for the Minuteman—are being heat-treated by Solar in this new furnace.

New Solar capability for giant space age components

THE LARGEST CONTROLLED atmosphere pit furnace in the nation is in operation at Solar. Capable of heat-treating and brazing assemblies of 9 ft in diameter by 30 ft in length, this furnace represents an important addition to Solar's

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design and fabrication problems. Write to Dept. G-113, Solar Aircraft Company, San Diego 12, California.



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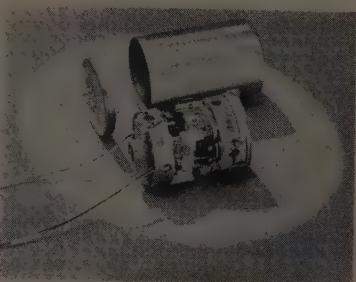
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GYRO has dual-rate design



Instrument and control package space needs can be materially reduced through use of a rate gyro that does the work of two units, says **Humphrey, Inc.**, Dept. S/A, 2805 Canon St., San Diego 6, Calif. The R-18 Series gyro has one motor to drive two separate wheels, making possible rate measurements about two different axis: two rate ranges about the same axis can be covered by the RG-20 Series.

A typical RG-18 application could be the measurement of both pitch and yaw; the RG-20 could assure required accuracy in instrumentation systems. For example, an RG-20 gyro that covers rate ranges from zero to 20 and zero to 200 deg/sec is, in effect, expanding the instrumentation

system's dynamic range from 100:1 to 500:1. The rate gyros have two independent pickoffs and are designed to withstand rigorous environmental conditions.

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POWER OSCILLATOR has unique circuitry

Elin Precision Power Oscillators may be obtained in the cabinet model (DK-102) or rack model (DK-102R). When desired, fast conversion from cabinet model to rack installation is made possible with a control panel kit which fits standard rack mountings. Precision stability of the unit is derived from a High-Q LC tuned circuit and special voltage-sensitive bridge combined in a circuit employing a large amount of negative feedback. A feature of the oscillator its ability to accommodate line voltage variations, says **Electronics International Co.**, Dept. S/A, 145 W. Magnolia Blvd., Burbank, Calif.

The DK-102 has virtually zero output impedance, it is designed especially for use where tuning fork frequency stability, absolute voltage values, extremely low output impedance, ultra-low distortion and high power capacity are required.

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more on page 229

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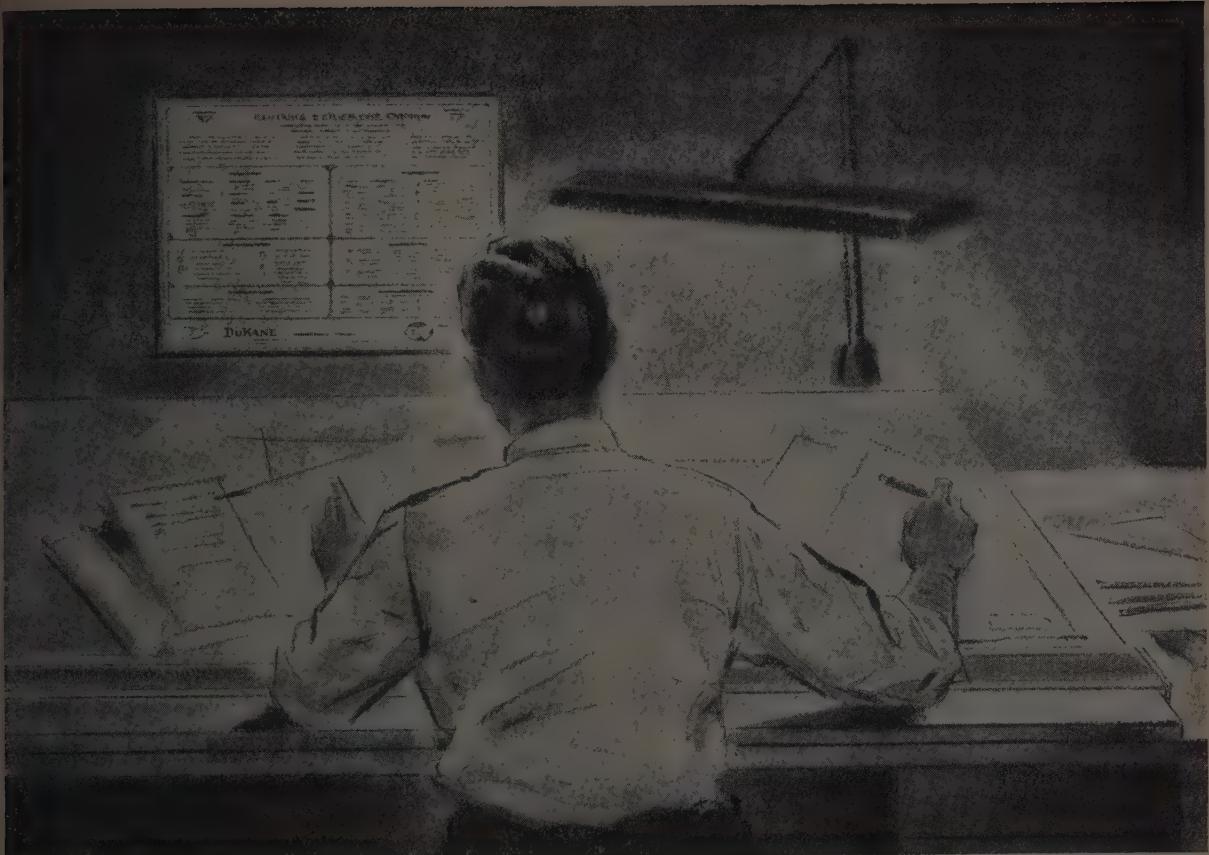
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SPACE/AERONAUTICS



How To Specify Ground Communications For a Missile Base

First, consider the supplier's experience and reputation. DuKane Corporation, pioneer in electronic communication systems, has installed ground communication equipment on such bases as White Sands, Patrick AFB, and Fort Churchill . . . *Second*, get help from an expert. DuKane's engineers are ready to help you. They've had wide experience in all phases of communications, including giving direct help to architects and consulting engineers in designing systems to meet any combination of needs . . . *Third*, consider equipment and flexibility. Of all the manufacturers of voice communication equipment, only DuKane makes a truly complete selection: intercom, public address, paging, background music, private automatic telephone, wireless paging for key personnel, emergency and evacuation systems, and hospital communication systems—in any combination to form an integrated system of any size, a few stations to hundreds.

For missile base ground communications, come to the experts . . . Write or wire DuKane Corporation, Dept. SA-1, St. Charles, Illinois. If you specify electronic equipment, ask also for DuKane's chart of electronic equipment symbols.

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May 1959

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IBM 704 COMPUTER permits General Electric engineers to analyze case stresses mathematically, correct design faults before fabrication begins. Computer is one example of advanced engineering capability which provides better case design, 230,000 psi strengths.



G-E ARC-SPRAYED TUNGSTEN nozzle liners (melting point: 6170°F) are now being incorporated into lightweight, advanced nozzle designs. Early hot tests indicate that extremely high nozzle performance can be attained, a potential provided by G-E advanced metallurgy.



INTEGRAL SKIRTS AND DOMES are roll-formed in General Electric solid propellant cases. Case halves are joined by single girth weld as strong as the case itself. General Electric is applying more than six years of roll-forming experience to case manufacture.



ROCKET ENGINES

New solid propellant cases with . . .

230,000 psi YIELD STRENGTH

Solid propellant rocket motor cases with yield strengths in the range of 230,000 psi are now under development at General Electric in conjunction with the Thiokol Chemical Corporation. These full-size cases are among the strongest and most advanced in the U.S. missile industry. They will be used to contain and direct the powerful forces generated in the powerplants of highly advanced solid propellant missiles.

Now underway at General Electric are equally advanced developments relating to high tempera-

ture tungsten throat liners for lightweight nozzle applications. Liners such as these are now being incorporated into advanced nozzle designs being developed by Thiokol Chemical Corporation.

General Electric's advanced rocket engine capabilities embrace engineering, metallurgy, manufacturing, research and development. They can meet your needs for high performance solid propellant motor cases and nozzle materials, or for liquid engine components.

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"aus-forming". Demonstration cases exhibit 340,000 psi yield strengths with elongations improved 10-12%. In nozzles, hafnium and tantalum carbide (melting point: 8700°F) combinations are being investigated.

The Flight Propulsion Laboratory Department's Rocket Engine Section is the nucleus of General Electric progress in rocket engines and their components. It is well-equipped, and it uses Company-wide capabilities and experience to speed advances. If you would like more information about the Section's products and capabilities in solid or liquid propulsion systems, please mail this coupon. Rocket Engine Section, General Electric Co., Cincinnati 15, Ohio.

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Rocket Engine Section
Flight Propulsion Laboratory Department
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terior is vital. Equally important is the extra care and precision with which "white room" relays are processed, tested, and inspected.

In General Electric's "white room" every precaution is taken to eliminate dust, dirt, and any other particles (as small as one micron) which might clog the contact points of hermetically sealed micro-miniature relays.

To maintain the controlled atmosphere within the room, dust counts and air samples are taken regularly. Employees wear special clothing and take air baths before entering the room

through the pressurized air lock. Temperature and humidity are continuously controlled and charted to provide optimum assembly conditions.

Obviously all relays do not require the exactness and care which is taken with these "white room" relays, but whatever your reliability requirements —there's a General Electric sealed relay to meet your needs.

Progress Is Our Most Important Product

GENERAL **ELECTRIC**

BALL VALVE
is light, small

These ball valves can be used in missile in-flight and ground support applications, according to Koehler Aircraft Products Co., Dept. S/A, 409 Leo St., Dayton 4, O. Their simple design and rugged construction have resulted in both small size and light weight.

The valves are said to be ideal for use with standard fuels and oils, high energy fuels, oxidizers, coolants, and cryogenics. The valves may be actuated by manual, mechanical or electrical means when they function as drain, selector, fill and flushing valves.

Write in No. 137 on Reader Service Card

CONVERTER
for pressure to frequency



The Osciducer miniature pressure-to-frequency converter provides a new approach to FM-FM telemetering, according to Solid State Electronics Co., Dept. S/A, 8158 Orion Ave., Van Nuys, Calif.

A temperature-stabilized silicon transistor oscillator is matched to a variable inductance diaphragm-type pressure transducer. The result is a complete in-line instrumentation module for the remote measurement of power. The Osciducer has three connections: 28 V dc at 2 ma, ground, and the output. The unit can be supplied for all IRIG channels. Frequency deviation is nominally $\pm 7.5\%$ of center frequency. Diaphragm- and flush-type transducers are available from 5 to 5000 psi differential, absolute, or gage.

Write in No. 138 on Reader Service Card

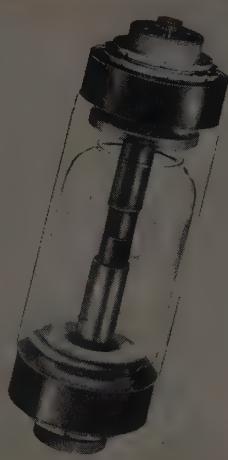
POTENTIOMETER
for high temperatures

Model 318, first of a new series of high temperature precision units, is available in resistance values from 10 to 50 K ± 5 per cent. Operating temperatures of this $\frac{1}{2}$ -in., 1.5-W potentiometer range from -55 to $+200$ deg C, says Daystrom Pacific, Dept. S/A, 9320 Lincoln Blvd., Los Angeles 45, Calif.

One watt is dissipated at 95 deg C. The unit meets or exceeds Mil-STD-202 Method 202 shock and vibration and NAS 710 noise specifications.

Write in No. 139 on Reader Service Card

VACUUM POWER SWITCHES
for high voltages



These switches, Types RH and RL, show much higher voltage and current ratings than previous vacuum switches. Individual switches will handle recovery voltages up to 48 kv peak when interrupting 600 amp rms, says Jennings Radio Mfg. Corp., Dept. S/A, 970 McLaughlin Ave., San Jose 8, Calif.

The units are available for continuous current ratings up to 600 amp and momentary surge current ratings up to 20,000 amp. They may be used in series for operating voltages up to 230 kv rms. The switches can also interrupt currents up to 4000 amp. Vital parts have been encapsulated to resist mechanical and electrical damage.

Write in No. 140 on Reader Service Card

POWER BRIDGE
for microwave measurement

Type 50 transistorized precision power bridge is a compact, light, battery-operated instrument capable of wave measurements, says Airborne Instruments Laboratory, Dept. S/A, 160 Old Country Road, Mineola, N.Y. The instrument is a self-balancing device permitting direct readings of RF power in watts and ohms.

The Type 50 is basically an audio oscillator and a bridge in a closed-loop circuit. The bridge balance, dependent on the total power in the thermistor, is maintained at a constant value made up of the power from the audio oscillator, the RF power, and a constant power caused by a dc bias current in the thermistor. As RF power is applied, the audio power decreases, until the power in the thermistor is restored to its constant value, thereby balancing the bridge.

Write in No. 141 on Reader Service Card

more on page 232



There's a G-E sealed relay for every circuit need—every reliability requirement

G-E miniature, sub-miniature, and micro-miniature relays combine small size with unusual reliability under severe temperature, shock, and vibration conditions to make them ideal for electronic jobs, both military and commercial. In addition to short shipment on production orders, G-E is equipped to give rapid service on samples and prototypes.



MINIATURE: Long-life type; rated 5 amps at 28 volts d-c at 85 C; in 2-, 3-, and 4-pole double throw and 6-pole normally open forms.



SUB-MINIATURE: 2 amps at 28 volts d-c, 115 volts a-c, double-pole double-throw; .651 in. in diameter, 1.6 in. long, weighs one ounce.



MICRO-MINIATURE: Crystal-can type, 0.5 oz. Rated 2 amps at 28 v d-c or 115 v a-c. Grid-space type (terminals spaced for printed circuits) available.

For more information contact your G-E Apparatus Sales Office, or mail coupon.

General Electric Company
Section C792-13
Schenectady, New York

Please send me a free copy of the sealed relay catalog.

Name _____

Address _____

City _____

State _____

GENERAL ELECTRIC

Write in No. 88 on Reader Service Card

BOEING'S BOMARC



... equipped, of course,
with Auto-Lite® Wire

America's leading airframe
and missile manufacturers specify
Auto-Lite Wire for quality and
extreme performance characteristics

Wire problems caused by high temperatures, fuels and lubricants, chemicals, and other agents are quickly solved when you call on Auto-Lite. At your service is America's foremost wire research facility—the Auto-Lite Wire Research Laboratory at Port Huron, Michigan. This ultra-modern laboratory is completely equipped to perform all qualification tests of wire for military specifications. For proven quality and reliability, specify Auto-Lite.

AUTO-LITE®

GENERAL PRODUCTS GROUP

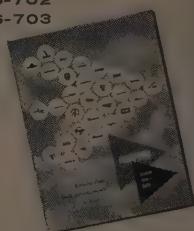
WIRE AND CABLE DIVISION

PORT HURON, MICHIGAN • HAZLETON, PENNSYLVANIA
TOLEDO, OHIO

Look to Auto-Lite for all classes
and types of aircraft wire meeting
these specifications:

MIL-W-5086A	MIL-W-16878C
MIL-C-7078A	NAS-702
MIL-W-8777A	NAS-703
MIL-W-7072A	

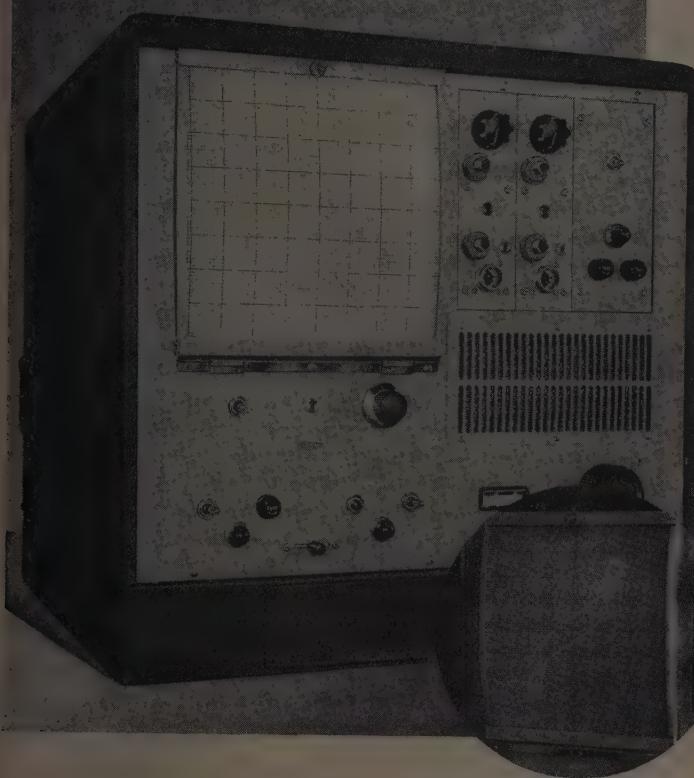
WRITE FOR
complete aircraft
wire catalog



Write in No. 89 on Reader Service Card at start of Product Preview Section

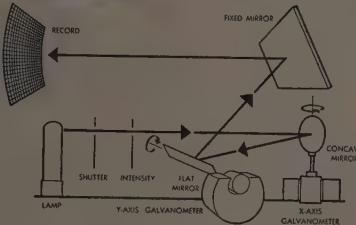
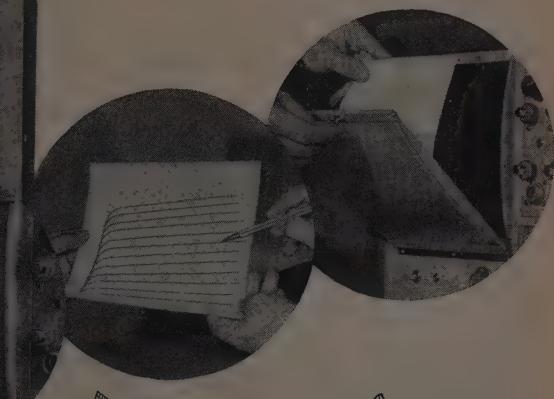
100 CPS X-Y RECORDING

with immediate
readout



THE NEW SANBORN MODEL 670 OPTICAL X-Y RECORDER HAS

- 1% linearity
- frequency response 3 db down at 130 cps independent of amplitude
- writing speeds to 2500 in/sec.
- 8" x 8" direct print paper chart
- trace monitoring on phosphorescent screen



X-Y RECORDING never before possible with electro-mechanical instruments can now be done with the new Sanborn Model 670 X-Y Recorder. Direct writing on ultraviolet-sensitive recording paper by a beam deflected by optical galvanometers makes possible the combination of fast writing speed and 130 cps frequency response not found in any other X-Y recorder. Transistor characteristics, acceleration and vibration of mechanical parts and events of similar short duration can be recorded with linearity of 1% of full-scale and at trace speeds as fast as 2500 inches per second. Square wave response exhibits no greater than 1/2% overshoot at any amplitude; sensitivities as high as 62.5 uv/inch (depending on preamplifier used).

PLOTS OCCUPY AN 8" x 8" RECORDING AREA and can be previewed or monitored on the instrument's phosphorescent screen. An Axis Record switch to print X and Y axes on the record, and a Beam Intensity Control to assure maximum trace clarity, are among the front panel controls provided. An 8" x 8" sheet of the ultraviolet-sensitive chart paper (stored in drawer at base of cabinet) is easily placed on the back of the hinged screen. Brief post exposure in normal room light is the only developing process.

OPTIONAL INTERCHANGEABLE PREAMPLIFIERS for each axis presently include the Model 850-1300B DC Coupling and Model 850-1200 Phase Sensitive Demodulator; a Carrier Preamplifier, High Gain Preamplifier and a time base generator are now in development. Driver Amplifiers are compact,

fully transistorized plug-in units with single-ended input and output. Galvanometers are low resistance, low voltage units of rugged, enclosed construction; sensitivity and damping are independent of coil temperature. Accessible, unitized circuitry also extends to the power supplies—a front-panel plug-in for both preamplifiers and a second supply for both driver amplifiers. A built-in blower provides constant, forced filtered air cooling. The Recorder can be rack mounted in 15 1/4" of panel space, or housed in its own 20" x 20" x 21 1/4" optional portable cabinet.

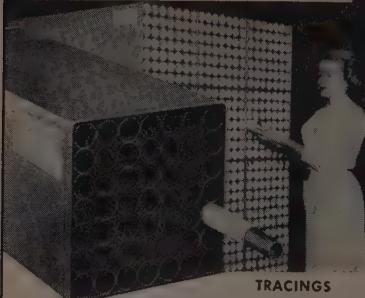
Ask your local Sanborn Sales-Engineering Representative for complete information on the Model 670 X-Y Recorder, or write the Industrial Division in Waltham, Mass.

**SANBORN
COMPANY**

INDUSTRIAL DIVISION
175 WYMAN STREET, WALTHAM 54, MASS.

Write in No. 90 on Reader Service Card at start of Product Preview Section

"AT-A-GLANCE" FILING SYSTEM



PRINTS • SHEET MATERIAL

QUICK, FILING AND WITHDRAWAL

Depth	11 1/4"	22 1/4"	30 1/2"	36 1/2"	42 1/4"
49 Tube	49AB	49CD	4930	4936	4942
1 1/4" I.D.	\$7.50	\$9.50	\$12.80	\$13.80	\$14.80
MODEL	25AB	25CD	2530	2536	2542
2 1/4" I.D.	\$7.00	\$9.00	\$11.80	\$12.80	\$13.80

Shipping Weight

Model 49 8 lbs. 12 lbs. 15 lbs. 18 lbs. 20 lbs.

Model 25 6 lbs. 10 lbs. 13 lbs. 15 lbs. 17 lbs.

ENAMELED DARK GREEN OR MED. GRAY State Color



Sold in Sets Only—

2 JR36 Per Set

• SOLD DIRECT ONLY Write to Dept. BP
F.O.B. St. Clair Shores, Mich. • Prescott 3-2515ROLL & FILE SYSTEMS, INC. P.O. BOX 3661 B
DETROIT 5, MICH

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GABB FC-3500

TANK
FILLER
CAP
AND
ADAPTER

MODEL NO.	TANK OPENING	O.D.	WEIGHT POUNDS	TYPICAL SERVICE	APPLICATIONS
FC-3510	1.5"	2.09"	.31	Synthetic oil	Military and Commercial Hydraulic Reservoirs
FC-3520	2.00"	2.80"	.69	Hydraulic oil	Military and Commercial Hydraulic Reservoirs
FC-3500	3.00"	3.75"	.80	Fuel, engine oil, water-alcohol	Military and Commercial Fuselage and Wing Tanks
37-3530	3.00"	3.75"	.719	Fuel, water-alcohol	Military and Commercial Fuselage and Drop Tanks, Fire Bombs
FC-3700	3.00"	3.47"	.456	Fuel, water-alcohol	Military Fuel Tanks
FC-4000	4.00"	4.62"	1.97	Fuel	Commercial Fuselage and Wing Tanks

The Gabb Adapter and Cap Unit, Tank Filler, is the first 3 inch assembly to successfully pass all the requirements of specification of MIL-C-7244 B (ASG). It is applicable to fuel, oil, water-alcohol and hydraulic reservoirs. This self-contained, flush mounted unit permits tank pressure relief by means of a lever action handle prior to removal of the cap from its adapter. Subsequent removal of the cap requires only a 35° rotation of the same handle. Write for free brochure No. 435.

GABB SPECIAL PRODUCTS INC.
WINDSOR LOCKS, CONN.

Write in No. 92 on Reader Service Card

RADAR TESTER
is portable

Model AN/GPM-25 radar system tester is a lightweight, portable unit providing convenient, rapid, comprehensive testing and evaluation of the operational capabilities of aircraft radar systems. In use, no physical connection is required between the aircraft and the tester, says General Mills, Inc., Mechanical Div., Dept. S/A, 1620 Central Ave., N.E., Minneapolis, Minn.

The tester weighs approximately 70 lb and has a volume of about 4 cu ft. Originally designed for bombing radar systems, the tester performs equally well as a navigation and weather radar tester. With minor changes, its uses can be extended to include fire-control radar.

Write in No. 200 on Reader Service Card

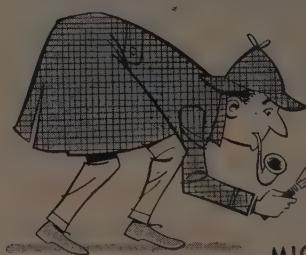
SMALL INDUCTORS
have high

Series 785 small, light toroidal inductors provide inductances from 1 milli-henry to 7 henries with a useful frequency range from 1 to 100 kc, says Arnold Magnetics Corp., Dept. S/A, 4618 W. Jefferson Blvd., Los Angeles, Calif.

Q-values for this series are exceptionally high—a typical 1-milli-henry inductor operating at 40 kc has a maximum Q of 240. Cases measuring 1 1/4 in. in diameter by 3/4 in. high and the unit weighs only 2.8 oz. The units are hermetically sealed and meet the specifications of Mil-E-5272-A and T-27-A.

Write in No. 201 on Reader Service Card
more on page 23

FOR LEAK-DETECTION DEVICES

NITROUS
OXIDEREADILY
DETECTS
MICROSCOPIC
LEAKS

Infrared determination of nitrous oxide provides a safe, sensitive and flexible method of leak detection. This method is not affected by usual atmosphere components such as moisture, carbon dioxide and hydrocarbons. In addition, nitrous oxide will not harm pieces being tested and is more economical than other gaseous agents.

OHIO NITROUS OXIDE: ODORLESS AND INERT • NONTOXIC
• NONCORROSIVE • NONFLAMMABLE • ECONOMICAL

FREE TECHNICAL AID is available in the use of nitrous oxide for leak detection. For further information, please request the following bulletins:

1A Chemical, Physical and Pharmacological Properties of Nitrous Oxide with Results of Corrosion Tests
1B Gas Service Equipment for Nitrous Oxide Supply

OHIO
Ohio Chemical

OHIO CHEMICAL & SURGICAL EQUIPMENT CO.
(A Division of Air Reduction Company, Incorporated)

MADISON 10, WISCONSIN



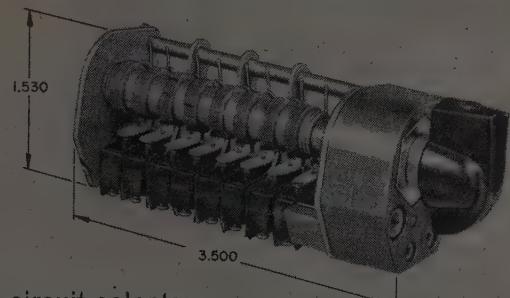
Write in No. 93 on Reader Service Card

SPACE/AERONAUTICS



A toggle switch
that mounts in $\frac{1}{4}$ sq. in.

2TM1-T weighs $4\frac{1}{2}$ grams. Ideal for use with printed and transistorized circuits and compact communication equipment. Operates dependably from -65° to $+200^{\circ}$ F. DPDT. Data Sheet 158.

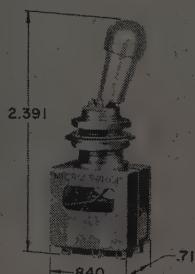


8-circuit selector
switch mounts in less than 1.75" dia.

"28AS" series switches have 2 to 4 positions, can control up to 8 circuits. Enclosed SPDT contacts, positive non-tease detents, sealed actuating mechanism. For aircraft, electronic and computer instrument panels. Data Sheet 162.

An ideal starter switch
for aircraft and
autopilot use

5ET1-6 is a completely sealed, momentary-action toggle switch which can be "electrically held" by means of a built-in solenoid. This permits remote electrical release of the lever. Switch can be manually overridden. Meets immersion test requirement of MIL-E-5272A. Wire leads conform to MIL-W-5086. Data Sheet 121.



A small, positive-locking,
3-position toggle switch

13AT2-A. Compact, pull-to-unlock toggle switch requires minimum behind-panel space. Widely used on airplane control panels, navigation systems and missile pad controls. Requires pull of .090 in. to unlock. Two SPDT basic switches shown. Data Sheet 160.

4 NEW precision switches meet a variety of specific aircraft and missile applications

Only at MICRO SWITCH does the designer of aircraft and missiles find such a wide variety of small size, lightweight, extremely reliable switches engineered to meet present and future needs.

MICRO SWITCH specialists work in close cooperation with the aircraft and missile industry . . . know what the requirements are and will be . . . and new switches are always in process of development and test.

Consult with MICRO SWITCH engineers experienced in switches for aircraft and missiles at any branch office. It can save you time and money.

MICRO SWITCH...FREEPORT, ILLINOIS

A division of Honeywell

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Honeywell

MICRO SWITCH Precision Switches

Write in No. 94 on Reader Service Card at start of Product Preview Section

Aeroquip

WEBLOCK

Straps

SIMPLIFY HANDLING OF ROCKET THRUST CHAMBERS AT ROCKETDYNE



Thrust chambers are palletized for handling.

Use of Aeroquip WEBLOCK Strap Assemblies can solve many materials handling problems. At Rocketdyne, division of North American Aviation, Inc., a simple nylon strap harness was developed to secure top-heavy rocket thrust chambers on pallets. Harness attachment is quick and easy. Tension is automatically locked with a pull of the WEBLOCK Strap, released with finger touch.

Outline your aircraft or missile tie-down requirements and let General Logistics provide simple, low-cost answers. Mail coupon below for details.



Ratchet Tie-Down Buckles

WEBLOCK Strap Assemblies

General **LOGISTICS**
A DIVISION OF **Aeroquip** CORPORATION

2929 Floyd Street, Burbank, California
Please send information on: S/A-5
 Ratchet Buckle WEBLOCK Straps

NAME _____
TITLE _____
COMPANY _____
ADDRESS _____
CITY _____ STATE _____

PRODUCT PREVIEW

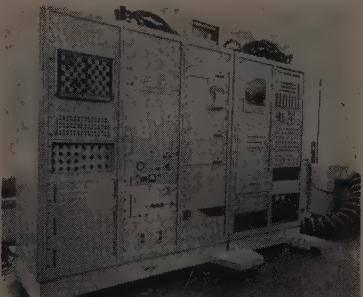
SERVO AMPLIFIER is transistorized

Model AMP-298 transistor servo amplifier has a maximum power output of 12 watts; 40-V rms into a 160-ohm, center-tapped load; and an adjustable voltage gain of 1000 at a constant input impedance of 50,000 ohms, according to Bulova Watch Co., Electronics Div., Dept. S/A, Woodside 77, N.Y.

The AMP-298 requires only 28 V dc power, operates from a carrier of 400 ± 20 cps and meets Mil-E-5400 and Mil-E-5272A. The unit operates over -55 to $+125$ deg C. The amplifier measures $1\frac{1}{16} \times 1\frac{1}{8} \times 3$ in. and weighs 9 oz.

Write in No. 202 on Reader Service Card

AUTOMATIC TESTER for systems evaluation



The universal automatic tester can rapidly evaluate within assigned limits dynamic functional capabilities of a weapon system, subsystem, or components without manual surveillance, says Systron Corp., Dept. S/A, 950 Galindo St., Concord, Calif.

The "Space System" provides for automatic IBM card programming and will accept 1000 inputs from any electronic subassembly. The unit features complete printed record, precision limit detection, in-line Nixie readout, and removable patchboard for control logic and switching of stimuli to the unit under test.

Write in No. 203 on Reader Service Card

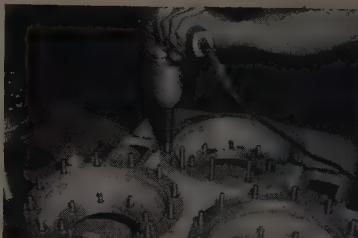
MICROWAVE EQUIPMENT for measurements up to 140

A complete line of microwave equipment is available to cover the range from 2.6 to 140 kmc. Instruments are functionally as accurate as equipment used at 90 kmc, says De Mornay-Bonardi, Dept. S/A, 780 S. Arroyo Parkway, Pasadena, Calif.

The line includes crystal multipliers, crystal mounts, E-H tuners, cavity wavemeters, standing-wave detectors, phase shifters, attenuators, elbows, twists, termination, standard gain horns, movable shorts, and magic tees.

Write in No. 204 on Reader Service Card
more on page 238

LOCTITE secures 98 studs against vibration



Locking studs with Loctite Liquid Sealant in transmission unit of jet aircraft starter.

Cast aluminum gear cases for jet aircraft starters are machined and assembled at The Black Rock Manufacturing Company, successor to Reed-Prentice Corp., Bridgeport, Connecticut. The 98 studs used in the unit are treated with Loctite Sealant to secure them against vibration. The jet starter units receive an input of 2500 rpm and develop output of 5000 rpm to each of three flexible shaft connections. Loctite was selected for this application since it provides a greater prevailing torque than any mechanical locking device. The locking strength of Loctite is not affected by the wide temperature ranges the unit encounters in arctic to tropic operation.



Stud thread is hand-dipped in shallow tray of Loctite, then positioned in casting for tightening. Three sizes of steel studs are used: $\frac{1}{4}$ "-20, $\frac{5}{16}$ "-18, and $\frac{3}{8}$ "-16.

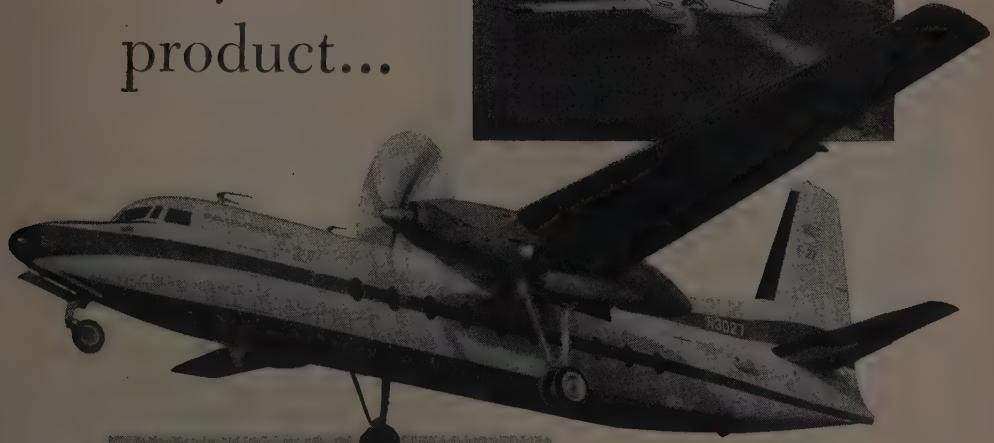


Two $\frac{1}{4}$ "-14 thread inserts are treated with Loctite to lock and seal in casting. The inserts provide non-abrasive threads for removable oil-drain plug.

LOCTITE Sealant is a thin liquid that hardens into a tough heat and oil-resistant plastic bond when confined between closely fitting metal parts. No amount of vibration will shake loose a LOCTITE treated threaded fastener, yet ordinary tools may be used to remove the part. LOCTITE is used to hold bearings, bushings, or hardened sleeves to shafts without press fit; seals joints against high pressure fluids. Write for literature and free sample.

LOGTITE **SEALANT**
AMERICAN SEALANTS COMPANY
161 Woodbine St., Hartford 6, Conn.
See LOCTITE Booth 1653—Design Engineering Show
Write in No. 96 on Reader Service Card
SPACE/AERONAUTICS

When buying aluminum for your product...



Commercial liners



Private planes

...it pays to
check with ANACONDA ALUMINUM

That's because Anaconda Aluminum combines the two features labeled "most wanted" by aluminum buyers in selecting a source of supply.

First: Anaconda Aluminum craftsmen will custom-produce your order, constantly checking and double-checking it to be sure your specifications are met precisely. We produce a full range of aluminum in all forms—pig and ingot, coiled and flat sheet, rod, bar, structurals, tubular and other extruded shapes.

Second: You'll like the way Anaconda Aluminum's flexible operations will schedule your order fast, and ship it on time. This flexibility is designed into Anaconda Aluminum's new facilities for this one reason—to give you the service you want!

Talk over your next aluminum order with your local Anaconda Aluminum representative . . . or write our General Offices, Dept. SA-5, Louisville 1, Kentucky.

***Every industry has one member
who specializes in customer satisfaction***



ANACONDA ALUMINUM COMPANY • GENERAL OFFICES, LOUISVILLE, KENTUCKY

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BASIC BUILDING BLOCKS

SERVO SYSTEM COMPONENTS



- Servo Motors—Frame Sizes 5-25
- Synchros and Resolvers—Frame Sizes 5-25
- Tachometers—Damping, Rate, Integrating
- Transistorized Amplifiers—High Temperature 2.5-16 watts

Synchros—Size 25—20 sec. max. error

HYDRAULICS



Servo Valves

- Two moving parts
- Anti-clogging—over size orifices, high pressure clearing
- Flow rates—0-5, 0-10 gpm

Systems

For hi-performance hydraulic or pneumatic missile control.

COMPUTERS



Navigational Computer

- Great Circle Course and Navigational
- Inertial Position
- Guidance
- Analog and Digital for Missile Applications

INERTIAL GUIDANCE



Rate floated gyro, single and two-axis accelerometers, first and second integrator, computers. Complete systems for direction and angular missile applications. Examples: high accuracy, long-term reliability, light weight, compactness.

GYROS



Miniature Floated Gyro

- Rate-floated Integrating; Spring Restrained
- Vertical—Miniature, Self-Contained
- Two Axis Free For Missile Control
- Directional, Conventional and Roll Stabilized
- 3 Gyro, 3 and 4 Gimbal Platforms
- North Seeking Theodolites

GROUND SUPPORT



Digital Logging System

Completely integrated ground support equipment based on unique Kearfott test equipment modules for analog or digital, manual, semi-automatic or fully automatic testing of components, sub-systems or systems.

MICROWAVE



- Waveguides, Strip Transmission Lines, Ferrite Components
- Radar and Asteroid Assemblies
- Transponder Systems, Target Simulators, Test Sets
- Traveling Wave Assemblies

Engineers:

Kearfott offers challenging opportunities in advanced component and system development

Kearfott

A
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PRECISION
COMPANY

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Midwest Office: 23 W. Calendar Avenue, La Grange, Illinois
South Central Office: 6211 Denton Drive, Dallas, Texas
West Coast Office: 253 N. Vinedo Avenue, Pasadena, California

Write in No. 98 on Reader Service Card at start of Product Preview Section

GPL data handling

equipment for the Federal Aviation Agency

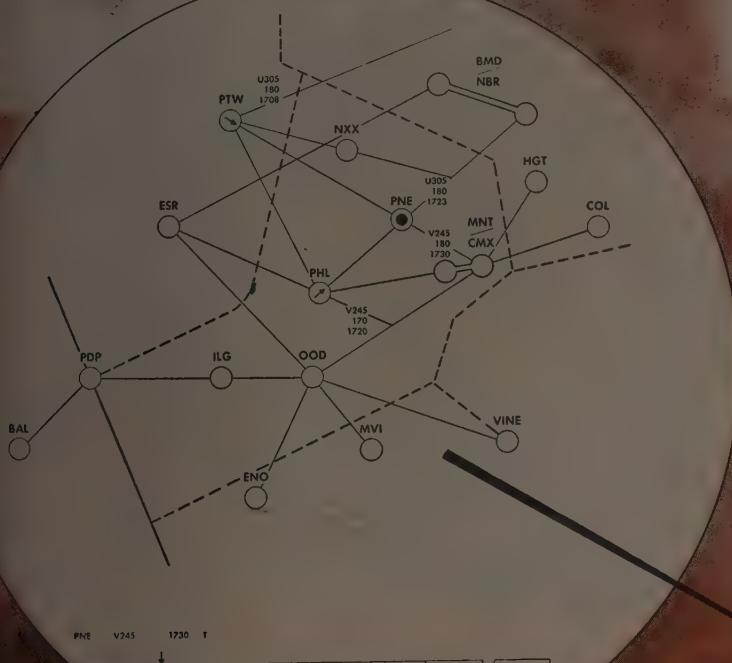


GPL's experience and ingenuity are at work assisting the FAA Bureau of Research and Development in the creation of a modern data processing central, the heart of tomorrow's air traffic control system. The central will receive up to 400 aircraft flight plans hourly, "remember" 1,000 such plans simultaneously and transmit 200 plans and 800 updates hourly to adjacent centers. Automatic processing and unique displays of such data will make significant contributions to the efficient control of aircraft in en-route, transition and terminal areas.

The FAA data processing central is just one of a number of airborne and ground-based programs reflecting GPL's capabilities in the data handling field. These programs are supported by GPL's proven ability to understand the customer's problem and capacity to anticipate future requirements. The GPL organization is "systems oriented," offers complete capabilities ranging from research, engineering and manufacturing to customer service.

Why not put these broad capabilities to work on your problem?

GPL Avionic Division/airborne navigators/missile guidance/radar/airborne computers/data handling systems/communications equipment/infra-red/closed-circuit TV.



- AIRCRAFT - COMMERCIAL PRIVATE, MILITARY
- ADC, SAGE, SAC
- MILITARY OPERATIONS OFFICES
- MILITARY TOWERS
- MILITARY-CIVIL RAPCON
- WEATHER BUREAU
- AIRLINE DISPATCH (RADIO) OFFICES
- CAA TOWERS
- AIR TRAFFIC COMMUNICATIONS STATIONS (ATCS)
- ADJACENT ARTCCS

ENGINEERS — GPL achievements have opened up some unusual research and development opportunities. Send resume to Personnel Director.



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MANUFACTURING

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RESEARCH / FLIGHT TESTING / ENVIRONMENTAL TESTING

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A Subsidiary of General Precision Equipment Corporation

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CHARACTERISTICS

ANALYSIS

1 Stainless Steel Ball and Race	RECOMMENDED USE For types operating under high temperature (800-1200 degrees F.).
2 Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3 Bronze Race and Chrome Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for Engineering Manual No. 551. Address Dept. S/A 59.

SOUTHWEST PRODUCTS CO.
1705-50, MOUNTAIN AVE., MONROVIA, CALIFORNIA

Write in No. 142 on Reader Service Card

SHUTOFF VALVE are stainless steel

These new motor driven, shutoff valves of all stainless steel construction, enabling them to be used for long-life bubble-tight flow control of all fluids and gases including the highly corrosive fuel and oxidizers, says Hydromatics Inc., Dept. S/A, Cedar Grove, N. J.

The pressure range handled by these valves is zero to 1000 psi, through a temperature span that includes the Cryogenic area, -320 to ± 160 deg. F. Design features of the valves available in a range of line sizes from $\frac{1}{4}$ to one in, include flo-ball valve design, hydromatics exclusive floating ball-seat valve arrangement with self-wiping and self-lapping action that insures long trouble-free life straight-thru flow, and valve ports.

Write in No. 205 on Reader Service Card

CYROGENIC PUMP is piston type

This compact, light-weight, piston type, aircraft pump is suitable for pumping liquefied gases such as nitrogen and oxygen. It has a demonstrated capability for pumping liquid nitrogen at pressures of over 3000 psi at speeds of over 3500 rpm. Sustained operating periods of over one hour have been obtained repeatedly without any form of lubrication, says Application Engineering Div., Sundstrand-Denver, Dept. S/A, 2480 W. 70th Ave., Denver 11, Colorado.

This pump has nine axial pistons and is a fixed displacement type. Metal parts are compatible with liquid nitrogen. Minor material changes can be incorporated to permit satisfactory operation using liquid oxygen.

Write in No. 206 on Reader Service Card

TRANSISTOR TESTER for lab and shop

This Model 102 Power Transistor Tester for rapid evaluation and testing of NPN and PNP power transistors at their normal operating power is designed both for laboratory use and for routine inspection by shop personnel, says Strand Engineering Co., Dept. S/A, 1354 N. Main St., Ann Arbor, Mich.

It measures collector current for zero emitter current (100) at base-collector voltages from zero to 75V; large signal current gain at collector currents up to 2.0 amperes, collector voltages from zero to 28 V and base currents up to 50 milliamperes; small signal current gain in the grounded emitter connection at any chosen operating point; and collector-base break-down voltage.

Write in No. 207 on Reader Service Card

TRANSDUCER weighs eight ounces

A new design telemetering position transducer provides a frequency change of four per cent in the associated oscillator circuit with each inch of shaft movement. This new unit forms the inductive portion of a Hartley type oscillator using a single triode tube. Output signals of up to ten transducers can be mixed and transmitted on a single channel to a remote receiver which will separate the signals by filtering, says G. L. Collins Corp., Dept. S/A, 2820 E. Hullett St., Long Beach 5, Calif.

The unit operates with a center frequency from 900 cps to 6000 cps. Frequency change is linear within one per cent over a stroke of 3.2 in. and frequency drift with temperature is less than 0.1 per cent per 100 deg F. Harmonic content is less than one per cent. The unit has an operating range of -90 to +275 deg F, is 6.5 in. long and weighs 8.2 oz.

Write in No. 208 on Reader Service Card

more on page 240

SPACE/AERONAUTICS

FIRST
IN
CLASS

GAR-3 *Super* FALCON

Playing follow-the-leader at 50 millisecond intervals, three *Super Falcon* missiles rocket ahead of their diamond-shaped supersonic shock waves. Homing in on radar, these deadly air-to-air missiles locate, track, and destroy their prey, with the same killer instinct of the birds they're named after.

Hughes Aircraft, the developer and manufacturer of these missiles and the Armament Control System that triggers them, specified Hitemp magnet and Teflon* wire for their missile, and Teflon wire for its control system.

Hitemp Wires, Inc., the leading specialist in high temperature insulated wires and cables, proudly answers roll call with those developers and manufacturers enlisted in defending our American birthright—*Freedom*.

HITEMP WIRES, INC.

1200 SHAMES DRIVE, WESTBURY, NEW YORK



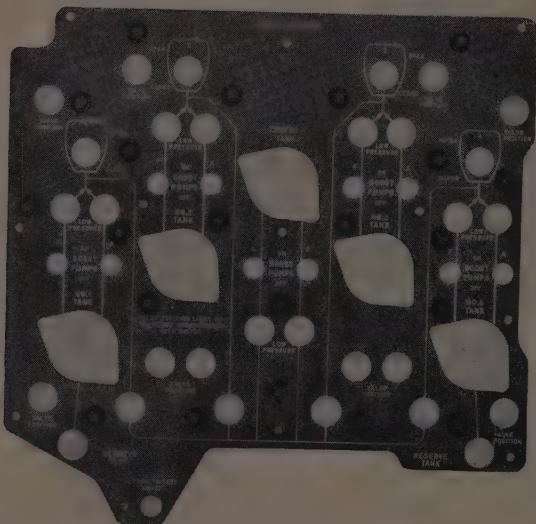
*Registered trademark for DuPont fluorocarbon resins.

Write in No. 143 on Reader Service Card at start of Product Preview Section

in the Boeing 707...



NEW INSTRUMENT PANEL GIVES ACCURATE FUEL DATA AT A GLANCE



Pilots of Boeing's 707 jet liners rely on new USR-engineered fuel system panels for quick, clear, concise information. The ready legibility inherent in the design of these integral edge-lighted panels makes it comparatively simple for the pilot to keep track of fuel load levels in jet flight where fuel management and control are always-critical factors.

In designing the Boeing fuel system panels, as in production of its entire line of edge-lighted dials and panels employing the Lackon® process, U. S. Radium utilizes experience and facilities unsurpassed in more than 30 years of service to component fields. The company offers a complete selection of "light-engineered" dials and panels for military and non-military applications. Technical consultation is available on request.

Request Bulletin 10.30-B5

USR

UNITED STATES RADIUM CORPORATION

MORRISTOWN, N. J. Offices: Chicago, Illinois and No. Hollywood, Calif. Subsidiaries: Radelin Ltd., Toronto, Canada and United States Radium Corp. (Europe), Geneva, Switzerland
Write in No. 144 on Reader Service Card at start of Product Preview Section

ANALOG COMPUTER is versatile

The Esiac is an analog computer designed to calculate and plot values of algebraic functions of a complex variable. It can be used in the design of servomechanisms, the synthesis of networks, the analysis of electromechanical devices, or in other problems requiring the solution of Laplace transforms of linear differential equations, according to Electro Measurements, Inc., Dept. S/A, 7524 S. W. Macadam Ave., Portland 1, Ore.

The computer is said to be particularly useful in transient analysis problems as an improvement on the graphical root locus technique. In frequency response analysis, the real frequency axis is scanned to plot gain or phase as a function of frequency, and various measures of system stability, such as *Q*, phase margins, and attenuation rate, are obtained.

Write in No. 209 on Reader Service Card

NOISE TUBE MOUNT for K-band



Designed to extend the range of microwave RF noise generating equipment, this new K-band, direct-reading noise tube mount provides a means of quickly measuring noise figures in systems operating from 18.0 to 26.5 Kmc, says Waveline, Inc., Dept. S/A, Caldwell, N.J.

The assembly incorporates a precision-calibrated attenuator directly marked in noise figure values.

Write in No. 210 on Reader Service Card

RECORDING PAPER gives data in 10 seconds

This photo-recording paper, Kodak Linagraph Direct Print Paper, that supplies data on in-flight missiles as quickly as ten seconds after the phenomena under observation take place is available from Eastman Kodak Co., Dept. S/A, Rochester 4, N. Y.

This photo-recording material may be used in conjunction with several new, special-type moving-mirror galvanometer oscilloscopes at trace velocities ranging from zero to 3000 cps. Tests indicate that the new paper will help avoid costly mistakes during in-flight and on-the-ground missile and aircraft tests taking immediate corrective measures when malfunctioning occurs.

Write in No. 211 on Reader Service Card
more on page 244



FIRST RULE FOR DELEGATING GROUND SUPPORT EQUIPMENT RESPONSIBILITY:

FIND AN AUTHORITY

Through 70 years of war and peace, St. Louis Car has developed, tested and built transport and handling equipment, railroad stock, amphibious vehicles, aircraft, special-purpose carriers and mounts.

Use this experience when you need transport and handling equipment; engineered from the systems approach to meet the specific operational objectives of your weapon.

Before you assign any transport and handling equipment work—from R&D to production—evaluate St. Louis Car. We welcome the chance to submit proposals.

ST. LOUIS CAR COMPANY

St. Louis 15, Mo.

Write on your letterhead for Information Kit SA-11.



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Jewels by Janitrol

If you are concerned with utilization, distribution, and control of high temperature, high pressure air for canopy seal, tank pressurization, fuel transfer, or any other interesting aircraft or missile application, this picture will interest you.

It shows an important facet of Janitrol's capabilities in the design and production of precision valves whose refinements and tolerances call for a jeweler's approach. The large family of Janitrol valves offers convincing evidence of our exceptional problem solving abilities in a field where reliability requirements are constantly being raised.

A complete picture of our capabilities is presented in a new brochure "Janitrol Resources." For your copy ask your nearest Janitrol engineering representative, or write: Janitrol Aircraft Division, Surface Combustion Corporation, Columbus 4, Ohio, BRoadway 6-3561. Also: Ft. Worth, WALnut 6-3386; Hollywood, HOlywood 3-6861; Washington, D. C., OLiver 4-2171; Philadelphia, MIDway 2-6342.

pneumatic controls • duct couplings and supports • heat exchangers • combustion equipment for aircraft, missiles, ground support



Write in No. 146 on Reader Service Card at start of Product Preview Section

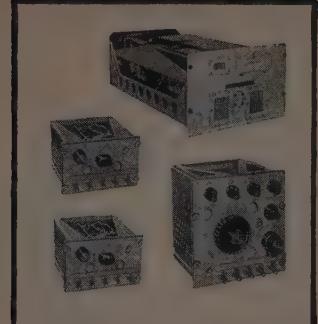
SPACE/AERONAUTICS

COMMUNICATIONS...

Radio Set AN/ARC-57 . . . designed and developed by *The Magnavox Company*, in conjunction with the Air Force, is an essential UHF communications system, providing the utmost in performance and reliability for the CONVAIR B-58.

It clearly demonstrates *The Magnavox Company's* ability to produce and work as a prime contractor on a complex weapons system.

MAGNAVOX capabilities are in *The Fields Of Airborne Radar, ASW, Communications, Navigation Equipments, Fusing and Data Handling . . .* your inquiries are invited.



PRODUCTS
THAT SPEAK FOR
THEMSELVES

Magnavox

MAKES THE B-58 TALK!



COMMUNICATIONS



RADAR



DATA HANDLING



ASW



MISSILES

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New Deutsch "Snap-In" Miniature Connectors

make RELIABILITY a REALITY



Here's a snap-in miniature you can trust to do what it's supposed to do. The new Deutsch DS Series of quick-disconnect connectors—with insertable and removable contacts and crimp-type terminations—has been thoroughly tested and *proved* under extreme environmental conditions.

proven
Check these advantages
against your design requirements

	DS FEATURES	YOUR DESIGN REQUIREMENTS
1 Pins and sockets	Easily insertable and removable	
2 Terminations	Crimp-type	
3 Contact retention	Withstands minimum of 25 lbs. pull	
4 Crimp strength	Greater than the wire itself	
5 Hand tools	Simple, fool-proof crimping, inserting and removal tools	
6 Interfacial seal	Continuous dielectric separation without voids; no bonding, reversion or shrinkage of inserts	
7 Environmental	Meets or exceeds MIL-C-26482 (ASG)	
8 Temperature	-100°F. to 300°F.	
9 Push-pull coupling	Positive ball-lock design; operates in direction of plug travel	
10 Contact size	Immediately available in #20 size; others to follow	
11 Shell size	Immediately available in 3, 7, 12, 19, 27, 37 and 61 contacts	
12 Interchangeability	Mates with existing Deutsch DM5000, DM6500 and DM9000 series	
13 Assembly	Delivered completely assembled except for insertion of contacts	

For complete technical information and test report, contact your Deutsch Representative or write us for Data File 5E.



The Deutsch Company
7000 Avalon Boulevard • Los Angeles 3, Calif.

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Write in No. 148 on Reader Service Card at start of Product Preview Section

PRODUCT PREVIEW

RECEIVER for 55 to 260 mc

Type 18A1 receiver has been designed for high performance in the 55-260-mc frequency range, says General Electronic Laboratories, Inc., Dept. S/A, 195 Massachusetts Ave., Cambridge, Mass.

Special features include a precision gear drive assembly for motor scan use, easily replaceable 416B and inductive tuning unit for simplified maintenance, plug-in tuning head, and an effective pulse AGC system. Write in No. 212 on Reader Service Card.

WAVEGUIDE SWITCH for X-band



Designed for the X-band, this microminiature waveguide switch is remotely controlled to provide a highly reliable means of switching a single waveguide input to either of two outputs, says Don-Law Electronics Co., Dept. S/A, Santa Monica, Calif.

RF switching under power, with a maximum VSWR of 2.1 during the switching cycle and 1.1 in either position over the entire frequency range, is achieved. Switching time is only 0.007 seconds, and isolation is a minimum of 50 db down. The switch weighs only 0.37 lb.

Write in No. 213 on Reader Service Card

WIREWOUND RESISTOR is sub-miniature

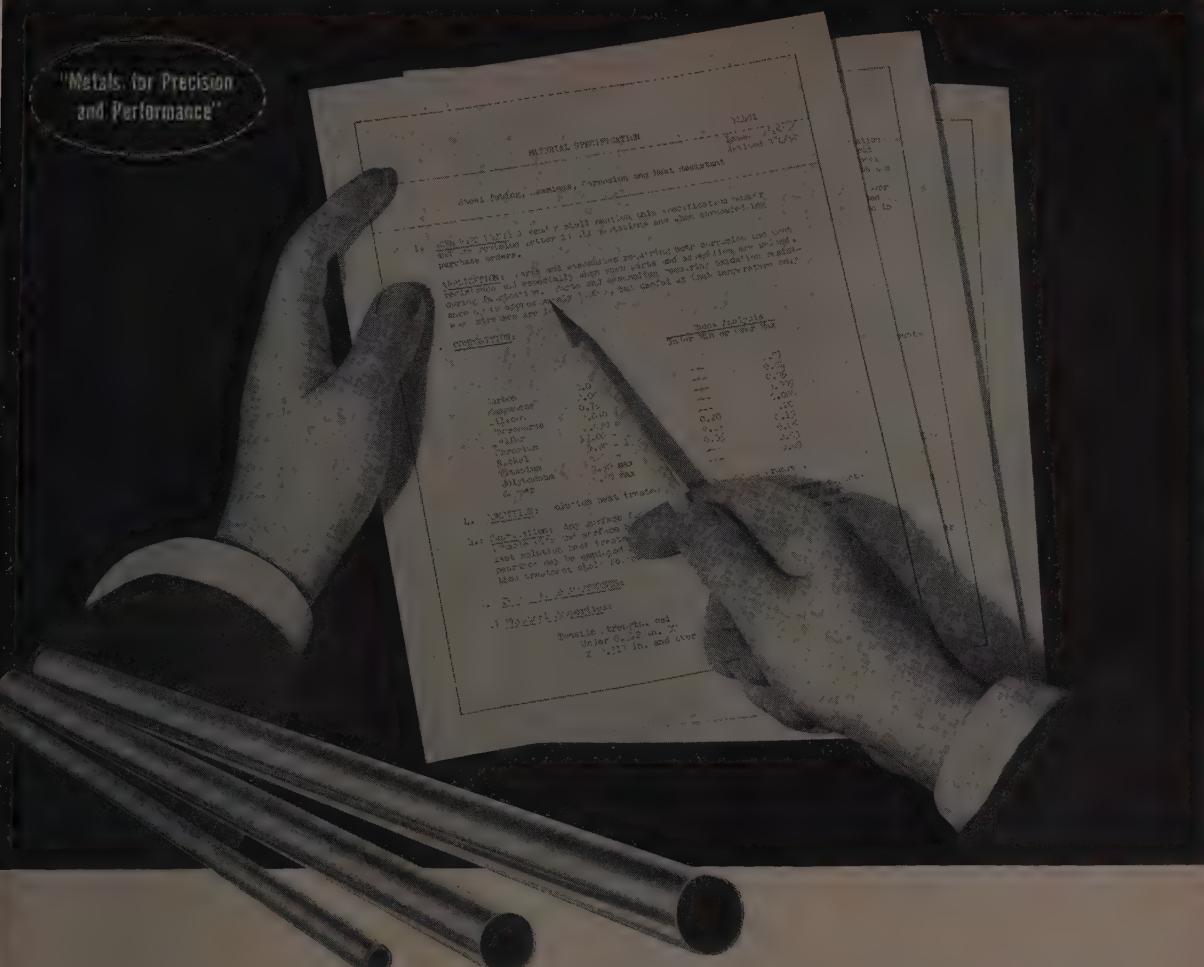
Measuring only $\frac{1}{8}$ in. in diameter by $\frac{1}{4}$ in. in length, Type 1282 precision resistor meets all requirements of Mil-R-93B, except physical size. The unit's wattage rating is 0.005 W at 125 deg C derated to zero at 145 deg C, says Daven Co., Dept. S/A, Livingston, N.J.

Resistance values are available from 10 to 100 K. Maximum voltage is 100 volts.

Write in No. 214 on Reader Service Card
more on page 246

SPACE/AERONAUTICS

"Metals for Precision
and Performance"



*your
individual
tubing specs
are a
BISHOP
specialty*

That special tubing you need doesn't have to be a frustrating problem — BISHOP delights in tackling tough specs. BISHOP is uniquely equipped to handle specials—long on experience and capacity, short on delivery. You'll get help within 24 hours from a Quick Service Team of sales, metallurgical and production experts—and unexcelled quality tubing . . . the finest made.

Briefly, the Bishop Line . . .

STAINLESS STEEL TUBING Seamless, Welded & Drawn	Mechanical, Aircraft, Capillary, Hypodermic also NEW Stabilized and L grades, precipitation hardening alloys	0.008" to 1.000" OD 0.003" to 0.083" wall
NICKEL & NICKEL ALLOY TUBING	All standard grades	up to 1.000" OD 0.065" wall max
TUBULAR FABRICATED PARTS	Flanged, flared, milled, slotted, swaged, threaded	
GLASS-TO-METAL SEALING ALLOYS	Low expansion alloys for glass sealing applications	
CLAD METALS & COMPOSITE WIRES	Base metals & precious metals in various combinations	
PLATINUM GROUP METALS	Fabricated products—chemicals	
CATALOGS, DATA SHEETS ON THE ABOVE SENT PROMPTLY ON REQUEST		

Send in your individual specs for prompt handling, thorough analysis, prices, deliveries. Write, wire or phone NIagara 4-3100 or call your local steel service center.



Tubular Products Division



J. BISHOP & CO.
platinum works

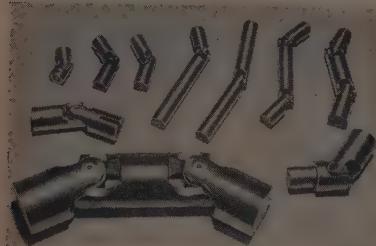
MALVERN, PENNSYLVANIA

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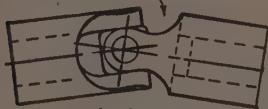
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INDUSTRY'S MOST COMPLETE LINE FOR EVERY SLOW SPEED APPLICATION

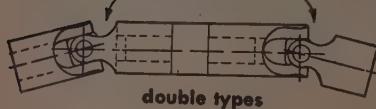


CONTOURED YOKE



single types

CONTOURED YOKE



double types

Check these features against your requirements:

Special Contoured Yoke—capable of operating at a maximum angular misalignment of 45° on hand-operated applications.

Static Torque—from 306 to 129,693 in.-lbs. at 12°, depending on size of joint.

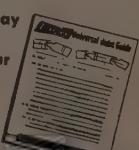
Horsepower Ratings—.54 to 207 at 100 rpm.

Tolerances—pins ground to .0005" ... forks concentric to within .001" ... precision accurate center blocks.

Standard Specifications—hub diameters $\frac{1}{2}$ to 4" ... bores $\frac{1}{4}$ to 2" ... lengths (single) 2 to $10\frac{5}{8}$ ", (double) 4 to $21\frac{1}{4}$ ". All specifications can be altered or special joints designed to individual requirements.

Get this handy guide

It's the quick and easy way to get the Universal Joint that is just right for your application. Request Bulletin 820.



LOVEJOY FLEXIBLE COUPLING CO.

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246

PRODUCT PREVIEW

COMMUTATOR SWITCH has 50 positions

Type 7122 commutator switch has 100 shorting positions or 50 non-shorting positions. The single-pole unit measures only $1\frac{1}{4}$ in. square and has a depth of $\frac{3}{8}$ -in., says Daven Co., Dept. S/A, Livingston, N.J.

Molded, wedge-shaped contacts are set into the epoxy with extremely close contact spacing tolerances. The commutator bars are solid silver alloy, and the rotor is beryllium copper, with a welded silver edge making contact with the stator.

Write in No. 215 on Reader Service Card

DAMPER-ACTUATOR in single unit



The Damperator is a dual-purpose hydraulic device that functions as both flutter damper and rotary actuator in installations on rudders and other control surfaces, says Houdaille Industries, Inc., Dept. S/A, 537 E. Delavan Ave., Buffalo 11, N.Y. The device is expected to benefit airframe manufacturers by virtue of weight and hardware savings.

An electronic servo system with a servo valve mounted directly on the Damperator provides precise rotary-motion control. Damping rates are uniform over -65 to $+180$ deg F. Automatic air bleeds and pressurized fluid replenishing are among other features.

Write in No. 216 on Reader Service Card

SOLDERLESS CONNECTOR for coaxial cable

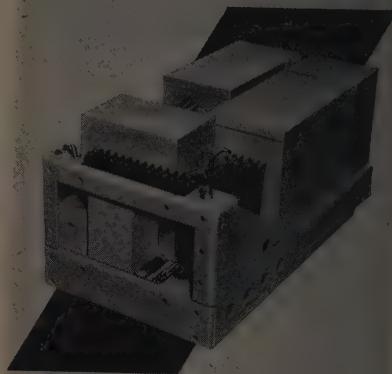
The Crimpee CR-8-U, a solderless 50-ohm, low-cost UHF connector for RG-8-U coaxial cable, meets all requirements of present UHF connectors but overcomes all objectionable features, says Elden Inc., Dept. S/A, 8105 Woodmont Ave., Bethesda, Md.

The unique construction of the unit assures 360-deg contact with cable braid and high mechanical strength.

Write in No. 217 on Reader Service Card

more on page 248

New ADVANCED DESIGN "B" LINE
60 AND 400 CPS



HIGH POWER TRANSISTOR MAGNETIC SERVO AMPLIFIER

For AC servo motor control—
50 watts to 3000 watts

FEATURING

- Extreme reliability
- Wider ambient temperature range
- Faster response
- Smaller size at higher power ratings
- Higher gains
- Improved core design
- Silicon rectifiers used exclusively
- Greater flexibility
- Ideally suited for operating with Diehl Servo Motors

Signal Input AC or DC
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Provisions for System Feedback • Completely Static • Output 115V AC Phase Reversible

For complete 60 cps and
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SPACE/AERONAUTICS

What is knowmanship— and what can it do for you?

As a prime contractor, your task becomes easier—the success of your project more certain—with an associate contractor who can fit into your "team" picture quickly and expertly. And this applies during initial planning stages—when you're first invited to bid on a major systems contract—as well as during production on the contract.

Such an associate contractor must be heavy on specialized talents—the kind that can't be acquired overnight. His background can come only from years of experience in sub-system research, development and production. It can come only from practical experience under the Weapons System concept.

Both these indispensable areas are thoroughly covered by Eclipse-Pioneer's KNOWMANSHIP—our word for the critical combination of technical knowledge, experienced management and specialized craftsmanship that an associate contractor must have to offer maximum value to a prime contractor.



Eclipse-Pioneer KNOWMANSHIP under the Weapons System concept dates from the very first contract of this type—in our association with Convair on the Air Force B-58 Hustler. Here, we developed and now supply from production Primary and Automatic Flight Control Systems, Stability Augmentation and Central Air Data Systems. Another of our major sub-system responsibilities is to the Martin Company for Inertial

Guidance, Stable Platform and associated equipment on the Army's Pershing missile.

Add in our physical resources—9,000 engineers and other highly skilled workers, 1,104,000 square feet of plant space, plus the most modern tools and equipment—and you have the significant *total* reason why Eclipse-Pioneer KNOWMANSHIP makes such a knowledgeable partner for prime contractors on advanced aircraft and missile development and production.

A letter, wire or phone call will bring our representatives to your office with complete facts about E-P associate-contracting capabilities.



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AND DIRECTORS • STABLE PLATFORMS • INERTIAL GUIDANCE • RADAR ANTENNA STABILIZATION AND TRACKING SYSTEMS

Write in No. 152 on Reader Service Card at start of Product Preview Section

POWER OSCILLATOR
for airborne equipment

DIFFERENTIAL
is very accurate

High accuracy in additive and subtractive operations has been claimed for a line of hollow-shaft, miniature, precision differentials. The devices have primary application in angular, angular velocity, sums, differences, sequence and other functions, says Fae Instrument Corp., Dept. S/A, 42-61 Hunter St., Long Island City 1, N.Y.

High speed rotation, minimum backlash, and low breakaway torque are featured. The units may be installed or removed from a gear train without disassembly of differential or instrument.

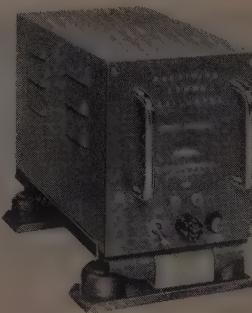
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INTERWOVEN CABLE
shows 20 db less radiation

This flexible cable has a unique interwoven, twisted, figure-8 weave which restricts the magnetic field normally radiated from a current-carrying wire, says Perfection Mica Co., Magnetic Shield Div., Dept. S/A, 1322 Elston Ave., Chicago 22, Ill.

A field or pickup reduction in excess of 20 db can be attained compared with a standard twisted cable of the same size and turns per in.

Write in No. 220 on Reader Service Card
more on page 250



Model ELIN DKI-102A, a two-watt-output power oscillator, is designed for shock-mounted installation in airborne equipment as an ultraprecise power supply for control equipment, says Electronics International Co., Dept. S/A, 145 W. Magnolia Blvd., Burbank, Calif.

The unit is also readily used in electronic ground support systems—input is 150 to 800 cps, 15 V ac. The maximum total distortion is 0.1%; frequency stability is 0.1%; amplitude regulation is 0.2%—under all conditions of line and load. Dimensions are for standard $\frac{1}{2}$ -ATR rack installation. The entire unit is designed to meet or exceed Mil-E-4158A.

Write in No. 218 on Reader Service Card

Here's
data
on the
New



DIAL HEAD AGASTAT®
time/delay/relays

These relays have recently been re-designed—improved in performance and appearance. So you'll want up-to-date specs.

This free folder gives complete details on all models. In it you'll find operating specs, timing ranges, contact capacities, dimensions, diagrams of contact and terminal arrangements, and data on mounting and installation accessories.

For your copy, write: Dept. A34-519.



ELASTIC STOP NUT CORPORATION OF AMERICA

Elizabeth, New Jersey

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SPACE/AERONAUTICS

shooting
for
the
moon!

When the first U.S. rocket to the moon will be in space, chances are it may be guided by some equipment designed and manufactured by the FALSTROM CO.

FALSTROM, one of the leading metal fabricators since 1870, manufactures chassis, weldments, housings and custom metal components that surpass the most stringent requirements of Mil Specs. In this way we help our nation reach for the moon . . . and beyond.

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**ENGINEERS AND SCIENTISTS
FOR COMPLETE
SPACE AND WEAPONS SYSTEMS**

Rarely does a corporation of United Aircraft's stature make available such key positions. Ordinarily these openings would be filled from within, but as the other divisions (Pratt & Whitney, Sikorsky, Hamilton Standard, Norden) cannot spare additional valuable staff men, these openings must be filled from the outside. You will work beyond ordinary boundaries on

MISSILE AND SPACE PROJECTS

Unusual, infrequently offered, high level positions for:

**ELECTRONIC ENGINEERS
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Please reply to Mr. John North, Engineering Dept.

MISSILES & SPACE SYSTEMS
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436 Main Street, East Hartford, Conn.



Check Employment Inquiry Form on Page 155

POWER RESISTORS

for FLIGHT USE

LESS SPACE—LESS WEIGHT

New lightweight, space-saving resistors permit substantial efficiencies and economies in aircraft and missile electronic apparatus. Units are mounted in direct contact with inner surface of chassis or case so that 25% to 40% of heat generated is emitted to atmosphere. Derating curves are available.

Available in the following ratings and sizes

Power Rating	Envelope Dimensions	Approx. Weight
40 Watts	7/8 x 1 3/16 x 4	.027 lbs. ea.
80 Watts	7/8 x 1 3/16 x 6	.040 lbs. ea.
120 Watts	7/8 x 1 3/16 x 8	.053 lbs. ea.
160 Watts	7/8 x 1 3/16 x 10	.067 lbs. ea.
200 Watts	7/8 x 1 3/16 x 12	.080 lbs. ea.

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Electro-Flex Heat, Inc.

83 WOODBINE ST., HARTFORD, CONN. (Chapel 6-5413)

"FIRST with STANDARD ELEMENTS"

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specialists in
HEATING
ELEMENTS



Insulation is silicone rubber—
operable continuously
at 450° F.
Mounting metal—
Alclad aluminum.
Connection tabs—
silver plated brass.
Special washers permit
bolt or rivet mounting.
Adhesive supplied
provides good thermal
transfer from resistor to
mounting wall.

DC SUPPLIES for missile testing

This line of dc power supplies was designed for test, checkout, and actual launching of several missiles, including the Thor and Atlas, says Perkin Engineering Corp., Dept. S/A, 345 Kansas St., El Segundo, Calif. Four models, the M-675, M-676, M-677 and M-678, are available.

Nominal output is 28 V. dc, with outputs ranging from 24 to 40 V at load capacities from 30 to 500 amp. Typical specifications include regulation of $\pm\frac{1}{2}$ per cent over the 24-32-V range and ripple of one percent rms. Ac input is a 208-115-4 wire system, three-phase, 60 cycle. Design features include ruggedized construction to allow mounting in missile vans.

Write in No. 221 on Reader Service Card

CAPACITORS for high temperatures

This stack-foil Fabmika Capacitor is designed for operation at high temperatures. It can function effectively at temperatures up to 260 deg C, and in special designs, up to 310 deg C says Sprague Electric Co., Dept. S/A, 295 Marshall St., North Adams, Mass.

There are four standard temperature ranges: from -55 to +125 deg C, +165 deg C, +200 deg C, and +260 deg C. The Fabmika Capacitors are available in four constructions: uncased (up to 200 deg C), uncased and clamped (up to 260 deg C), cast epoxy housing (up to 200 deg C), and drawn metal case (up to 260 deg C standard and 310 deg C). Sizes on the cast epoxy and drawn metal case constructions are furnished for particular applications on request.

Write in No. 222 on Reader Service Card

TIME DELAY RELAY for -55 to +125 deg C

A new line of sub-miniature time delay relays combine the features of sub-miniature size, light weight, environmental resistance, maximum reliability, and timing accuracy never before available, says Tempo Instrument Inc., Dept. S/A, 240 Old Country Rd., Hicksville, N.Y. Through the use of transistors and RC time-constant circuits, all moving parts except relay contacts have been avoided.

Standard models are available with time delay periods from 0.01 to 60 sec, delay occurring between application of current and pull-in relay contacts. Timing accuracy is ± 10 per cent of nominal thru a temperature range of -55 to +125 deg C. Units are of ruggedized design vibration-proof up to 20g's and 2000 cps and will withstand shock of 40g's for 11 ms.

Write in No. 223 on Reader Service Card

PRESSURE GAGE for telemetering

Designed for use with either standard or wide band subcarrier oscillators, these small size single coil variable inductance pressure gages exhibit extreme stability in the presence of high mechanical shock and vibration, says Tavis Instruments, Inc., Dept S/A, 1901 E. Walnut St. Pasadena, Calif.

Frequency shift with temperature is less than 0.005 per cent per deg F and sensitivity change is less than 0.02 per cent, full scale, per deg F over the range from -85 to ± 250 deg F. Absolute, gage, and differential units in pressure ranges from 5 psi to 5000 psi are available for use at carrier frequencies from 1.8 Kc to 70 Kc. The units weigh less than 2.5 oz. and are $\frac{1}{8}$ in. diameter by 1.8 in. long.

Write in No. 224 on Reader Service Card

more on page 252
Write in No. 157 on Reader Service Card
SPACE/AERONAUTICS

more and more engineers specify

CINCINNATI SUB-ZERO
Testing and Chilling Equipment

HERE'S WHY

- **100% reliability**—every unit unconditionally guaranteed
- **custom-built**—to your own requirements
- **compact design**—saves valuable floor-space
- **superior construction**—numerous extras are built in
- **economy of operation**—stands up to rigorous use with little servicing.

Write describing your requirements.
We'll send literature promptly.

Representatives in all major industrial cities.

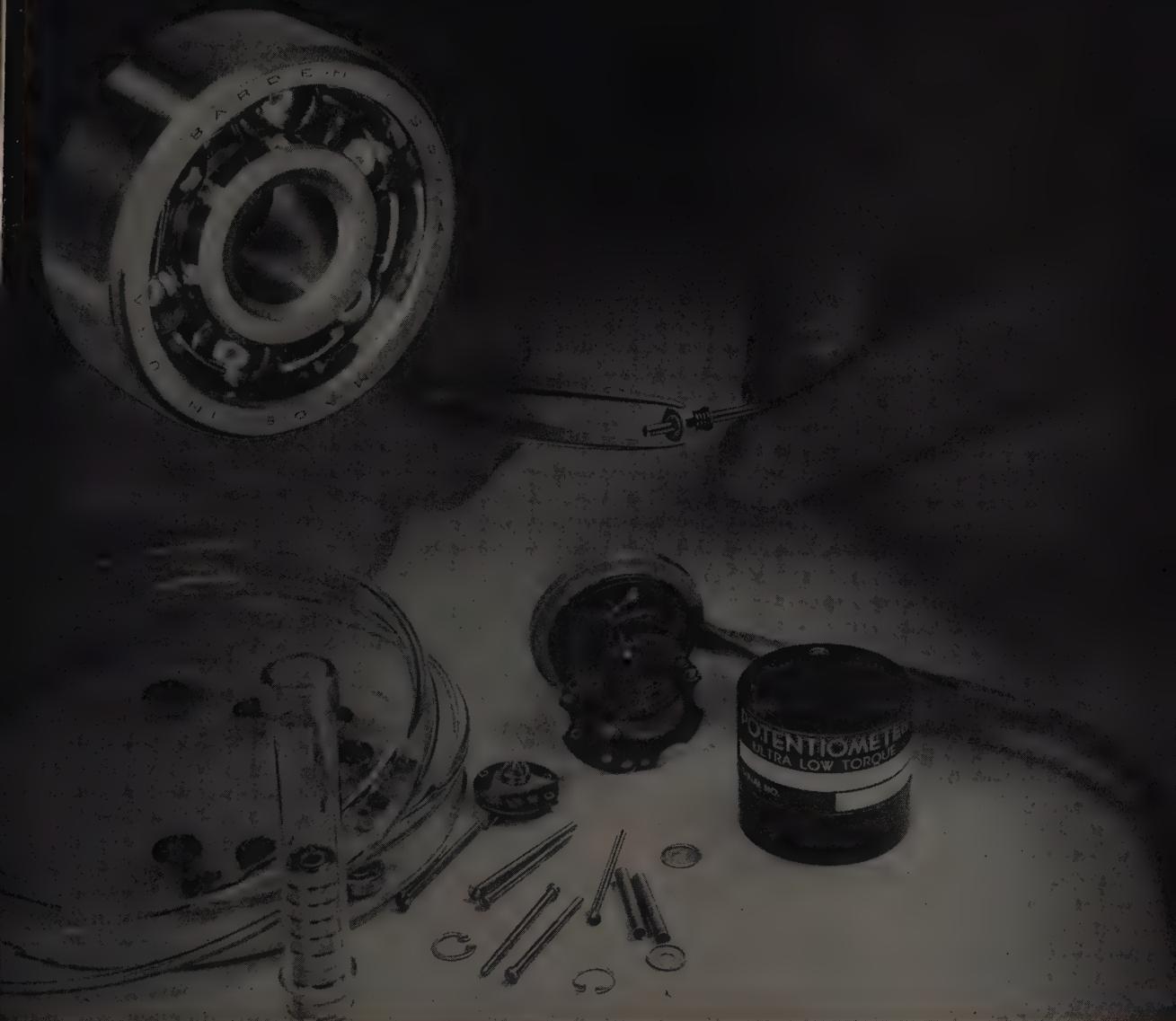
Member: Environmental Equipment Institute

CINCINNATI SUB-ZERO PRODUCTS

General Office & Plant
Reading Rd. • Cincinnati 29, Ohio

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250



Barden Precision SR1-4 miniature bearings as used in a linear or non-linear potentiometer.

BARDEN miniature-size bearings are built with instrument precision

Precision-built potentiometers require concentric, smooth-running wiper contacts and ultra low torque characteristics to provide accurate and rapid response to small motivating forces.

Barden Precision miniature-size bearings have the inherent concentricity, smoothness and low torque values to assure this sensitive response and electrical accuracy.

Barden Precision miniature bearings are built to the same high standards of consistent quality as Barden's larger instrument sizes. **Barden Precision** means not only dimensional

accuracy but performance to match the demands of the application.

Your product needs **Barden Precision** if it has critical requirements for accuracy, torque, vibration, temperature or high speed. For less difficult applications, Barden predictable performance can cut your rejection rates and teardown costs.

Write today for your copy of Catalog Supplement M1 which gives dimensions, performance and engineering data on **Barden Precision** ball bearings $\frac{5}{8}$ " O.D. and smaller.

THE BARDEN CORPORATION

75 E. Franklin St., Danbury, Connecticut • Western office: 3850 Wilshire Blvd., Los Angeles 5, California



The Talyrond, a super-accurate measuring device, is used by Barden as a development tool; as a standard for correlation of other quality control instrumentation; as a gage for ultra-precise bearing parts. It measures roundness and waviness to five millionths of an inch.

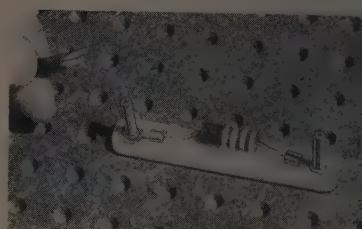
METER
checks bearings

An average-reading meter and three peak-level trigger circuits are used in this instrument to evaluate the running quality of precision instrument ball bearings, according to Leitch-Huard Corp., Dept. S/A, Stark & Commercial Sts., Manchester, N. H. The General Motors-developed Vibra-Meter measures, after converting it to an electrical signal, the axial component of forces produced in a bearing rotating under a light thrust load.

The peak-level circuits are set at different levels, each represented by an indicator, which lights when the signal generated by the bearing roughness exceeds the level set. The trigger circuits and the average meter roughness indications are automatically locked in at the 100-rpm bearing test speed. The Vibra-Meter test head, a separate unit, attaches to the meter indicator cabinet by means of a four-ft cable. A design for easy servicing and adjustment is featured in the continuous duty instrument.

Write in No. 225 on Reader Service Card

SETS
build circuits quickly



WHATEVER THE SHAPE

ADAPTER

ENGINE MOUNT

9 1/2" SUPPORT

CHAMBER

TURBINE WHEEL

FOR SUPERIOR QUALITY AND PROPERTIES

Misco OFFERS **MONO-SHELL** and **V/V**



Valve casting and its MONO-SHELL

Misco's MONO-SHELL process permits manufacture of many new components once avoided by conventional investment casting systems. Castings by MONO-SHELL weighing 25 lbs., 12" dia. x 6" high, poured in air or vacuum by the DOUBLE-V system are commonplace today.

Surface qualities in the as-cast condition average 70-90 R.M.S.

MONO-SHELL permits wide selection of stainless steels and high temperature alloys with improved metallurgical qualities and properties.

Write us for specific data on alloys produced by MONO-SHELL; or better still, submit your drawings to our Engineering Staff for a value analysis.

Misco Precision Casting Company

MISCO

Sales Offices in Principal Cities

PRODUCERS OF AIRCRAFT AND INDUSTRIAL INVESTMENT CASTINGS

Write in No. 158 on Reader Service Card at start of Product Preview Section

The ErecTronic system, consisting of precision-drilled Duron pegboards, electric and electronic components mounted on high-impact polystyrene bases with dual plug-in pins, and phosphor bronze jiffy connectors, is designed to permit R&D engineers to check out new circuitry ideas in minutes, says Science Electronics, Inc., Dept. S/A, 195 Massachusetts Ave., Cambridge, Mass.

There is no soldering nor wire preparation required to build circuits; paper work and model shop delays can be eliminated.

Write in No. 226 on Reader Service Card

STRIPPING TOOL
for copper braid wire

This tool strips nylon sheathing from plated copperbraid wire (Mil-W-16878C) without scoring the braid. Two high-speed steel blades sharpened to the helix angle of the twisted wire penetrate the nylon to the proper depth, says Stavid Engineering, Inc., Dept. S/A, Plainfield, N.J.

The angle of the cutting blades and the elongated slot in the wire guide induce a spiral motion of the wire as it is drawn over the area to be stripped.

Write in No. 227 on Reader Service Card

RADIO INTERFERENCE FILTER
is subminiature



Model 5833 radio interference filter is rated at up to 2 amp at 28 V dc at 105 deg C and will filter most dc motors as stated in Mil-I-6181B, says Double E Products, Dept. S/A, 208 Standard St., El Segundo, Calif.

The unit has a $\frac{1}{16}$ -in.-diameter case (1 $\frac{1}{2}$ -in. long) and a $\frac{5}{16}$ -24 threaded mounting bushing.

Write in No. 228 on Reader Service Card
more on page 254



(left) Navy Polaris AX-1 flight test vehicle at beginning of launch. Lockheed's Polaris fleet ballistic missile is more than a year ahead of original schedule.

(below) Nation's first successful re-entry tests were conducted with the Lockheed X-17.



STRUCTURES AND DESIGN

Expanding the Frontiers of Space Technology



Design is a challenging and growing field at Lockheed dealing with varying phases of mechanical, electrical and structural problems.

Some of the most difficult structure problems in the missile industry were successfully met by Lockheed design engineers for the Navy Polaris IRBM, where the unique launching environment—water—aggravates the normal critical missile requirements of strength minus weight.

Major emphasis in structures concerns the design of re-entry bodies, thrust termination, and underwater launching devices. Other significant work has been accomplished in the mechanical design of vehicle frames, flight controls, hydraulic, ignition and separation systems; and in the electrical design of equipment for test, check out, arming and fusing, guidance, and telemetry.

As systems manager for such major, long-term projects as the Navy Polaris IRBM; Army Kingfisher and Air Force Q-5 and X-7 and other important programs, Lockheed engineers and scientists face a double challenge—to improve existing designs and devise solutions to new problems.

Scientists and engineers of outstanding talent and inquiring mind are invited to join us in the nation's most interesting and challenging basic research and development programs. Write: Research and Development Staff, Dept. E-16, 962 W. El Camino Real, Sunnyvale, California. U.S. Citizenship required.

"The organization that contributed most in the past year to the advancement of the art of missiles and astronautics." NATIONAL MISSILE INDUSTRY CONFERENCE AWARD

Lockheed

MISSILES AND SPACE DIVISION

Weapons Systems Manager for the Navy POLARIS FBM; DISCOVERER SATELLITE; Army KINGFISHER; and Air Force Q-5 and X-7.

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIF.
CAPE CANAVERAL, FLORIDA • ALAMOGORDO, NEW MEXICO • HAWAII

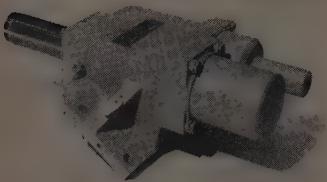
SERVO MOTOR TACH has greater range

Designed to meet BuOrd Mark 16 specs., Type 18-MTG-6302 servo motor tach exceeds these specifications with operating temperature from -54 to 725 deg C and with starting voltage as low as $1\frac{1}{2}$ V, says John Oster Mfg. Co., Dept. S/A, 1 Main St., Racine, Wis.

The unit consists of 115 V 400 cycle two phase size 18 servo motor with a precision size 15 tachometer integrally mounted on the motor shaft. The servo motor has a high torque to inertia ratio, a no load speed of 4700 rpm, a rotor moment of inertia of 5.73 gm/cm^2 , develops a stall torque of 2.4 oz in. with a power input of 9.2W per phase and is rated for continuous duty at stall.

Write in No. 229 on Reader Service Card

ANTENNA BUFFER for radar



This hydraulic buffering device dissipates the energy of extreme shock loads, says Houdaille Industries, Inc., Hydraulics Div., Dept. S/A, 537 E. Delavan Ave., Buffalo 11, N.Y.

Installed at the limits of radar antenna travel, the buffer protects the sensitive electronic and mechanical elements of the radar unit from damage caused by overtravel.

Write in No. 230 on Reader Service Card

SMALL CRYSTALS feature stability

Excellent stability in miniature, low-frequency, shock-mounted crystals have been obtained in the ST-70NXS, the smallest unit of its type available, according to Electronics Div., Bulova Watch Co., Dept. S/A, Woodside 77, N.Y. The series is designed for missile, aircraft and other problem environments.

Frequency range of the series is 100 to 250 kc, and frequency tolerance is ± 0.15 percent over a -55 to ± 90 deg C range. The one-oz device is mounted in a HC-6/U military-type holder, and overall size is $\frac{3}{8} \text{ x } 1\frac{1}{32} \text{ x } \frac{1}{32}$. The crystals meet all environmental specifications of MIL-E-5272, MIL-E-5400, and MIL Std. 202. Special vibration tests show they withstand 20 g's up to 2000 cps.

Write in No. 231 on Reader Service Card
more on page 257

Check Employment Inquiry Form P. 155

Fellow Engineers and Scientists:

My company has asked me to tell you of the unusual opportunities in operations research at System Development Corporation. These range from positions for engineers and scientists who would like to develop their skills working in a team under an experienced leader to opportunities for those who are looking for positions of leadership. I hope that the following account of our work will lead you to inquire for further information.

Briefly, SDC's business is automated decision-making systems. More fully, we develop large scale, computer-based information processing systems in which the computer is used as an on-line, centralized control element for a system operating in real-time. At this stage of the art these systems are semi-automatic, the man-machine type in which man shares the repetitive control function with the computer. Our work is concept-oriented, rather than hardware-oriented, and deals with problems of over-all system design, data processing development, and man-machine system training.

The most fully developed large-scale semi-automatic system is the SAGE (Semi-Automatic Ground Environment) Air Defense System. We have a major responsibility in the development of SAGE. Our experience and unique team skills have led to diversification of our activities; we now have important contracts for other major military and government systems vital to our country. The demand for our services is reflected in our growth from 70 to more than 2,700 employees since 1955, and the intriguing possibilities of automated decision-making are only beginning to be realized.

In this brief message, I can only suggest the variety of operations research problems at SDC. Perhaps the most important point is that this variety is limited only by the imagination and initiative of our scientists.

Some examples of areas of work are: (1) allocation of decision-making functions between man and machine for optimal system performance; (2) measures of system capacity and system performance; (3) exploration and evaluation of design changes by operational gaming; (4) quality control and testing of operational computer programs; (5) allocation of computer capacity among several system functions; (6) scheduling and costing of production of operational computer programs; (7) optimal assignment of mixed weapons to targets.

SDC recognizes the importance of a well planned research program for the vitality and future of the company, and we are carefully organized to carry out such a program. The following are some areas our operations research people are involved in: (1) simulation and operational gaming techniques in problems of control systems; (2) information retrieval and theory of information processing; (3) medical data processing; (4) universal language for computer programming; (5) logistics. We have unusual facilities for research at SDC—these include one of the largest computer facilities in the world and outstanding simulation laboratories.

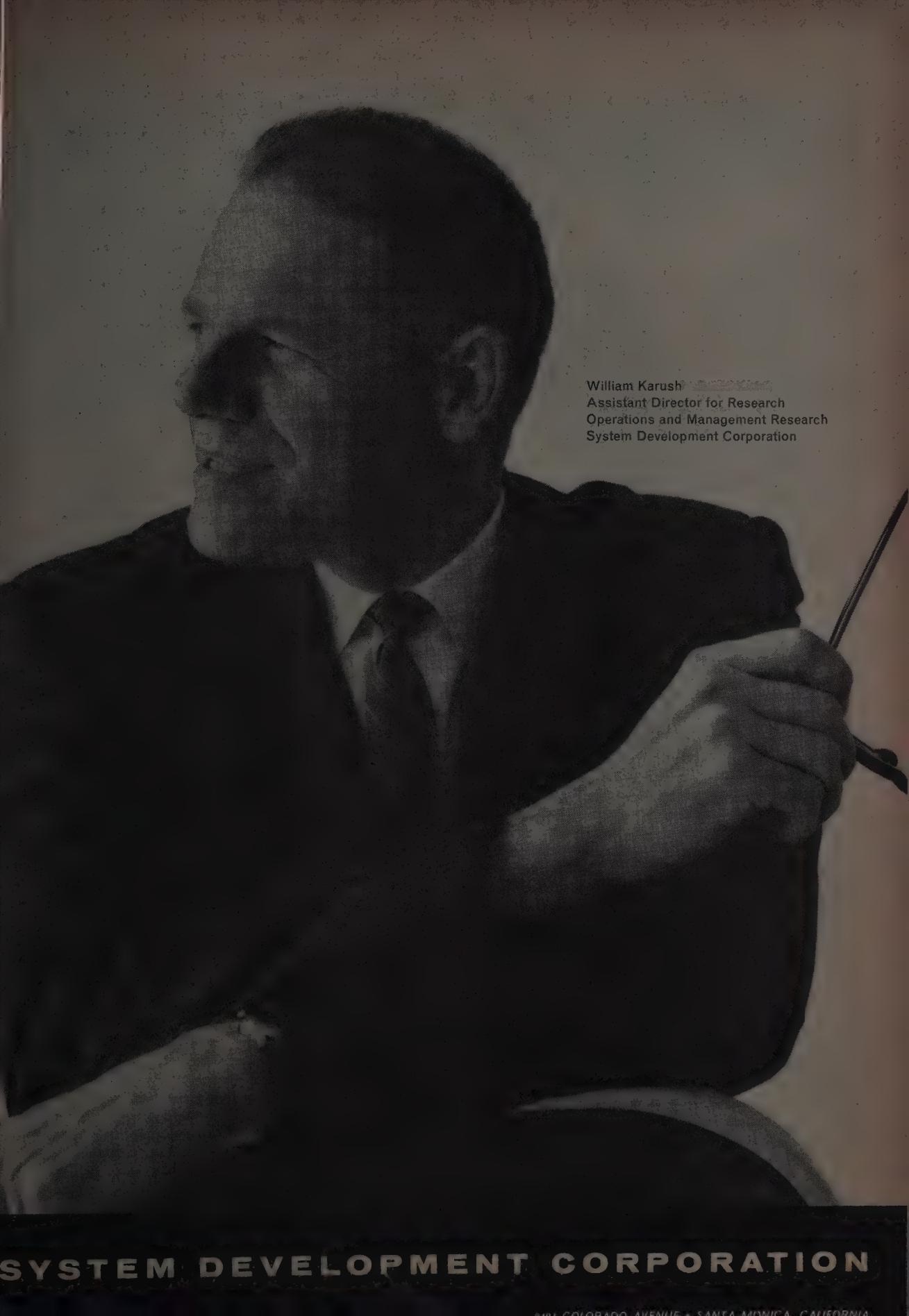
We have given considerable thought to organizing the activities at SDC to provide for professional development and self-expression. Operations research professionals are carefully assigned so that their individual talents are matched with company needs. These assignments are reviewed regularly to make sure that developing talents are directed into new company opportunities. We regard the publication of research articles and participation in professional societies as activities important to the company. We encourage new ideas and provide the time and means to explore them.

SDC is one of the leaders in a field which will have a remarkable technological and scientific development. It is a new and vigorous company with a bright future. I encourage you to join us.

Please write Mr. R. W. Frost at the address below if you wish to pursue this invitation.

William L. Nash





William Karush
Assistant Director for Research
Operations and Management Research
System Development Corporation

SYSTEM DEVELOPMENT CORPORATION

3811 COLORADO AVENUE • SANTA MONICA, CALIFORNIA

RENÉ 41

fine WIRE

*... almost too fine to see,
too versatile to believe!*

- For use in the 1200°-1800° F range
- Tensile strength to 425,000 psi

From Cannon-Muskegon — a major move in special metals development! Now the amazing properties of René 41 are yours to utilize in fine-wire form. This new vacuum-melted, high-temperature product is just .0015" in diameter . . . half the thickness of a human hair. One ton could circle the earth three times, four tons would reach the moon!

Yet thin as it is, René 41 fine wire has unusual strength. Under cold reduction, tensile strengths to 425,000 psi have been obtained. And even at 1800° F it maintains high oxidation resistance, exceptional tensile and yield strength.

René 41 fine wire is currently being used in the form of screens, filters, cables, strainers and casings for high-temperature applications.

René 41 and other vacuum-melted high-temperature alloys are also available in sheets up to 48" wide x 120" long, and in thicknesses down to .010. Bar stock is available up to 3" in diameter, and foil down to .001 in thickness.

Our metallurgists will furnish any help or data you may desire. Write Cannon-Muskegon.



CANNON-MUSKEGON CORPORATION

Lincoln Avenue • Muskegon, Michigan, U.S.A.

METALLURGICAL SPECIALISTS

Write in No. 161 on Reader Service Card at start of Product Preview Section

SPACE/AERONAUTICS

**MISSILE CHUCK
has large diameter**

A 46-in. dia is featured in the universal pinch-type Horton chuck for holding large diameter missile parts. The concentric expanding and contracting action of the 12 equally spaced universal jaws makes the chuck useful for rounding out and holding the thin-walled sheet metal missile tanks and parts for trimming, facing, turning, and welding operations, says United-Greenfield Corp., Dept. S/A, New Haven, Conn.

The chuck is raked to repeat within .002 in. T.I.R. at the diameter to which the top jaws have been machined, and can be used on vertical or horizontal lathes.

Write in No. 232 on Reader Service Card

**ACCELEROMETER
has wide dynamic range**

Accelerations on the order of 0.0017 g will produce a ten millivolt output change in the new Model 24614 AC Accelerometer made by G. M. Giannini & Co., Inc., Dept. S/A, 918 E.

Green St., Pasadena, Calif. Available in a variety of low natural frequencies, and in ranges from ± 1 g to ± 20 g, this instrument provides accurate, consistently reliable ac output proportional to linear acceleration parallel to its mounting base.

Wide dynamic range is provided by a full scale output of six volts and a maximum null of 0.015 V (of which at least 90 per cent is harmonic).

Write in No. 233 on Reader Service Card
more on page 259

*check valves with
superior sealing for
surge flows,
high flow rates and
opening blasts*



P200 Series Check Valves

*specifically designed
by Circle Seal for perfect
performance in high
pressure gas or liquid
service. For 0-3000 psi
or 0-5000 psi.*

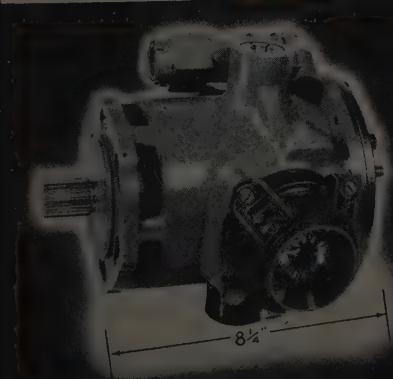
*Write today for
free engineering data!*

2181 East Foothill Boulevard/Pasadena, California

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**FLIGHT
ACCESSORY
POWER**



Write in No. 163 on Reader Service Card at start of Product Preview Section

**HIGH RELIABILITY...
Constant Speed Drives on Navy A4D**

Over 100,000 flight hours have demonstrated the exceptional reliability of the G-E ball-piston design. Not one failure of the pumping elements has ever been reported in service. Mission reliability of .9996 is the result of unmatched design simplicity.

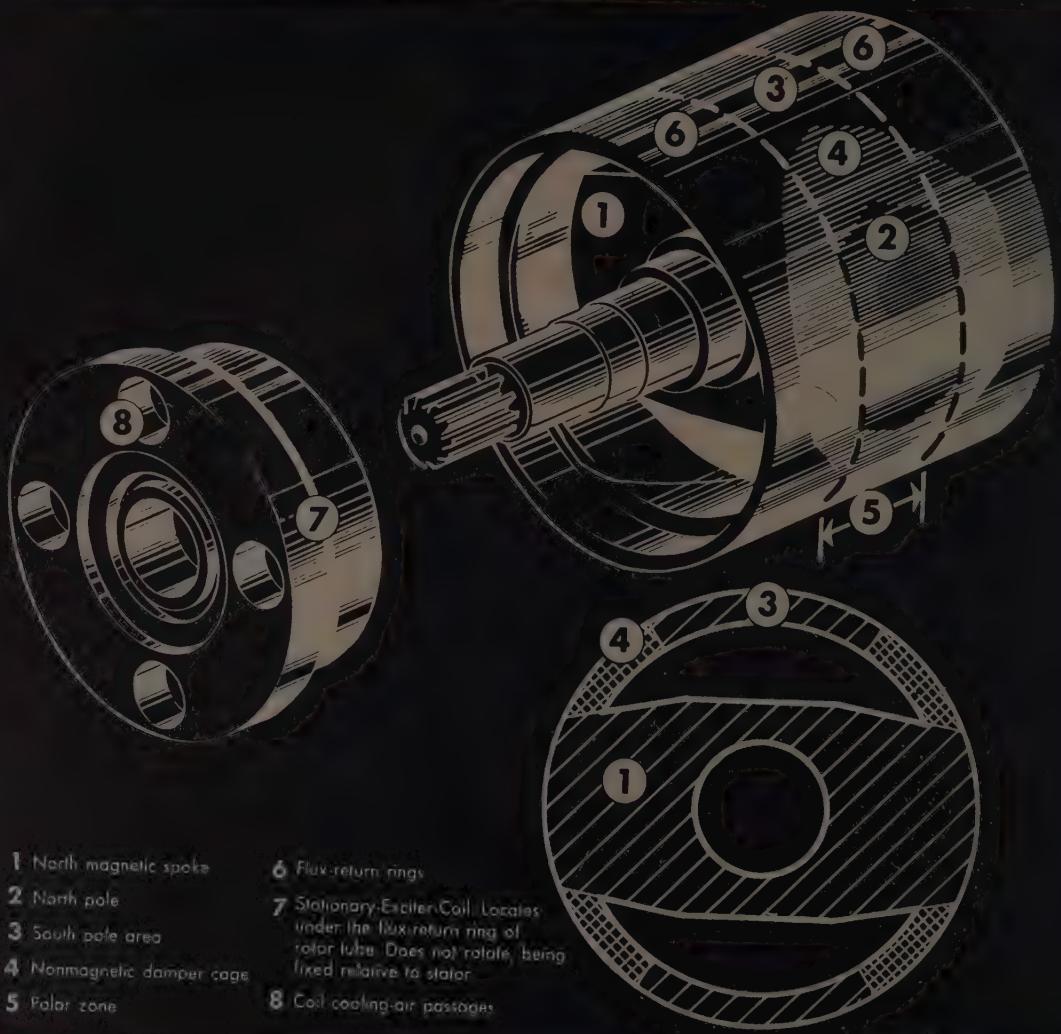
The lightweight, compact units also insure a low overhung moment

and are compatible with any aircraft engine. In addition, they can be used with any make of 400-cycle a-c generator.

Drives using the unique ball-piston principle are today delivering precisely controlled speed to the electrical systems aboard the Convair 880 and McDonnell F4H, as well as the Douglas A4D. 231-26

Progress Is Our Most Important Product

GENERAL  ELECTRIC



- 1 North magnetic spoke
- 2 North pole
- 3 South pole area
- 4 Nonmagnetic damper cage
- 5 Polar zone
- 6 Flux-return rings
- 7 Stationary-Exciter-Coil. Locates under the flux-return ring of rotor hub. Does not rotate, being fixed relative to stator.
- 8 Cool cooling-air passages

Picture of sophistication . . .

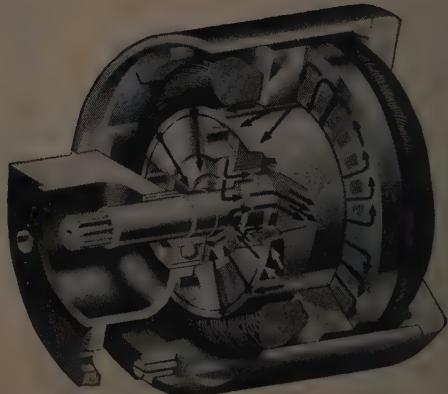
It shows why SECSYN* works twice as long as any comparable-purpose machine . . . needs almost no maintenance whether used to deliver kva, kw or hp. SECSYN's long-life secret is rotor simplicity: no brushes . . . no rotating rectifiers . . . no rotating copper field windings. And if liquid-cooled, SECSYN does not require coolant seals.

From this proved sophistication comes an ultra-speed range (up to 100,000 rpm) and extreme-temperature capability.

You can use SECSYN as an a-c generator to produce frequencies from 60 cps to 7000 cps . . . from 0.5 kva thru 125 kva. Or the design can be adapted as a d-c generator, synchronous motor or constant-speed motor.

If you're looking for the most economical and reliable power source yet designed, let's review your need in light of SECSYN. Contact Jack & Heintz, Inc., 17634 Broadway, Cleveland 1, Ohio.

*Stationary-Exciter-Coil SYNchronous brushless machine.



Cutaway of complete SECSYN showing flux paths.

JACK & HEINTZ, Inc.
SYSTEMS FOR AIRCRAFT, MISSILES AND GROUND SUPPORT

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CONVERTER
for high speed data



High speed transmission of digital data from magnetic tape over to voice-quality telephone circuits can be done using the 768H-1 Kinetape converter with the TE-206 Kinplex data system, according to Collins Radio Company, Dept. S/A, 2700 W. Olive, Burbank, Calif.

Data rate is 300 characters per second with either IBM or Univac tapes. Both instruments are completely transistorized and employ etched circuit cards. New signaling techniques allow superior signal-to-noise performance and efficient spectrum use. Error detection and correction is automatically done by error coding and data retransmission techniques.

Write in No. 334 on Reader Service Card

RADIO TRANSMITTER SYSTEM
weighs less than 3 lb

This tiny, complete radio transmitter system is a combination of microphone and radio transmitter contained in a lighter, more compact

package, says Yuba Consolidated Industries, Inc., Systems Div., Dept. S/A, 351 California St., San Francisco, Calif.

The miniaturized sonde is com-

pletely transistorized, and printed circuit techniques are used to reduce the weight to less than 3 lb.

Write in No. 335 on Reader Service Card
more on page 261

ADEL LINE
SUPPORTS

designed for every application

CLAMPS • BLOCKS • HARNESS STRAPS
for military & industrial systems & equipments

They cut maintenance and replacement costs . . . performance and reliability far beyond specifications of any other Line Support.

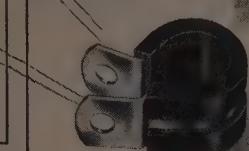
 CLAMPS provide cushioned, vibration absorbing support for cables, tubing and piping.

 BLOCKS provide resilient support for multiple grouping of lines to eliminate failures.

 HARNESS STRAPS embody heat and cold resistant material for temperatures far above +550°F to well below -90°F.

For safety, flexibility, durability and economy SPECIFY ADEL and be certain of getting the best possible service from products that are the result of advanced engineering design and the most modern production techniques.

A COMPLETE LINE . . . SERVICE-FITTED, TESTED AND APPROVED SPECIFICATIONS ARE AVAILABLE TO AIRCRAFT, MISSILE AND ORIGINAL EQUIPMENT MANUFACTURERS . . . WHAT ARE YOUR REQUIREMENTS?



Reliability
ADEL PRECISION
PRODUCTS

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DISTRICT OFFICES: Burbank • Mineola • Dayton • Wichita • Dallas • Toronto

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Huntington 4,
West Virginia

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**FLIGHT
ACCESSORY
POWER**



HIGH RELIABILITY...
Cartridge Turbostarters on USAF B-57

With a million and a half successful starts during a five-year period, G.E.'s solid-propellant turbostarters have demonstrated their dependability and have proven their adaptability to varied operating conditions.

Over 2000 cartridge starters have been produced and are being used

every day at tactical bases all over the free world.

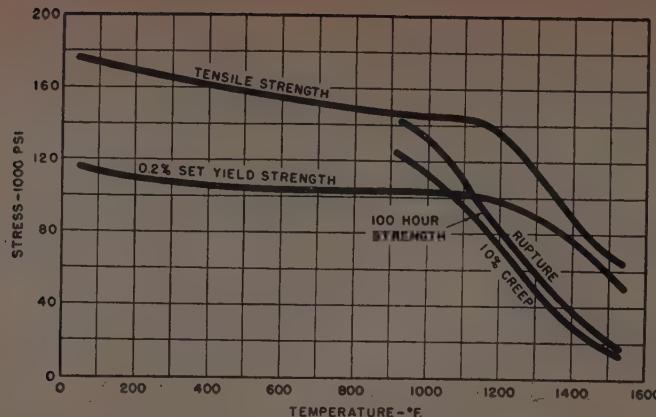
Solid-propellant, fuel-air, and cartridge-pneumatic turbostarters are available, with torque ratings from 350 to over 1000 foot-pounds—to meet the requirements of any gas turbine engine now flying or contemplated.

231-27

Progress Is Our Most Important Product

GENERAL  **ELECTRIC**

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Graph shows high tensile, creep and rupture strength Incoloy "901" provides at 1000°-1400°F.

New standard alloy... "super" alloy properties!

In the 1000°-1400°F range, Incoloy "901"** iron-nickel-chromium alloy has properties which match those of "super" alloys.

Its nominal composition is 40% nickel, 13% chromium, 2.40% titanium, 6.00% molybdenum. The balance: iron.

Incoloy "901" alloy was especially developed for rocket and gas turbine components. This alloy provides high tensile, creep and rupture strength (see graph), good oxidation resistance and favorable expansion characteristics at elevated temperatures.

Solution treatment extends time-to-rupture

In bar stock, time-to-rupture for a given stress and temperature can be extended by a high temperature solution treatment before aging. Sheet is best formed in the annealed condition and aged by a short time (2 hr) treatment at 1400°F.

Other new high temperature alloys developed by Inco

In addition to Incoloy "901", Inco has developed four other high temperature alloys which deserve attention in missile design. They are: Inconel "713 C"** nickel-chromium alloy, Inconel "700"** age-hardenable nickel-cobalt-chromium alloy and Inconel "702"** aluminum-containing nickel-chromium alloy. For basic data on all five, write to the address below.

**Registered trademark

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street

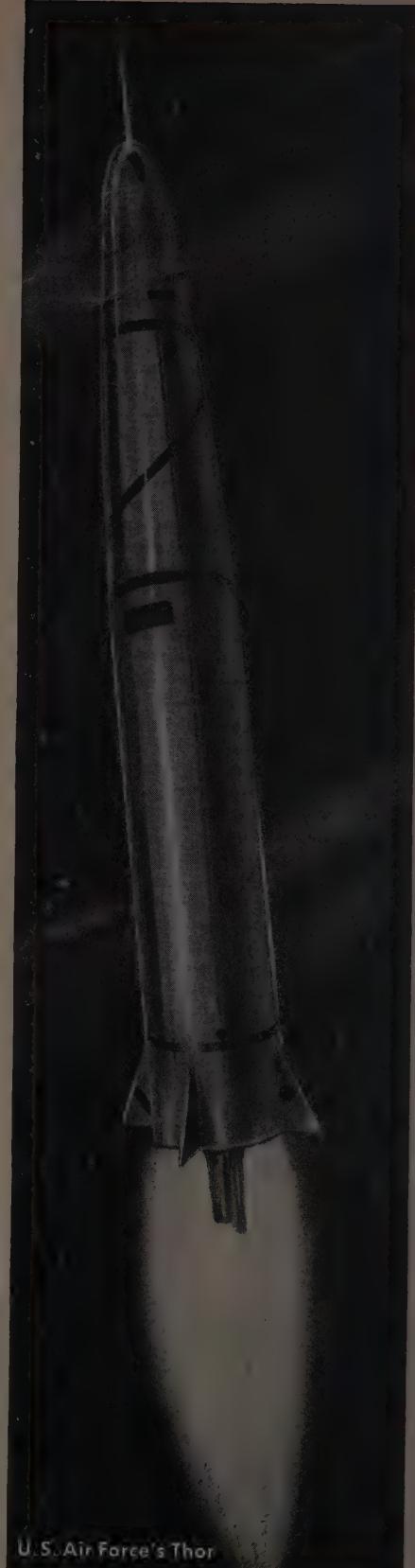


New York 5, N. Y.

INCO NICKEL ALLOYS

NICKEL ALLOYS PERFORM BETTER LONGER

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NUMERICAL INDICATOR TUBE
has 10,000-hour life



Type B-5031, an ultra-long-life Nixie indicator tube, is the first in the series of all-electronic indicator tubes which present the 10 numerals in a common in-line viewing area, says Burroughs Corp., Electronic Tube Div., Dept. S/A, P.O. Box 1226, Plainfield, N.J.

The B-5031 is similar in mechanical and electrical characteristics to the standard Type 6844-A. The only change which is required to make the tubes interchangeable is a reduction in the value of series anode resistance under rated operating conditions.

Write in No. 336 on Reader Service Card

ISOLATION SYSTEM
solves shock problems

Isolation from shock and vibration for such devices as gyroscopes, missile mountings, supersonic sled mountings, and airborne instruments, may be

obtained through an isolation system that will withstand high vibration loads, says Maryland Div., Litton Industries, Dept. S/A, 4900 Calvert Rd., College Park, Md.

The device incorporates cable-mounted structures designed with low natural frequencies to allow maximum

absorption of shock, along with attenuation of vibration loads. The isolator, which can be adjusted in the field to meet changes in load conditions, can isolate shocks of up to 50 g.

Write in No. 337 on Reader Service Card
more on next page

**for control cable
or aircraft
tiedown systems
use ...**



Wickwire Aircraft Control Cables and Wickwire Rope for aircraft tiedown systems are sold through



warehouses at:

Atlanta, Ga. • Chicago, Ill. • Cleveland, Ohio
Dallas, Tex. • Los Angeles, Calif. • Miami, Fla.
San Francisco, Calif. • Teterboro, N.J.

For your ordering convenience and quick-delivery needs, Air Associates Division of Electronics Communications, Inc. maintains large stocks of Wickwire Wire Rope in warehouses located at or near airports.

For the best in quality and service, order Wickwire Rope through the nearest Air Associates warehouse.

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**FLIGHT
ACCESSORY
POWER**

Superior dependability and continuing product excellence is based on advanced technology, extensive operating experience, and competent servicing in the areas of:

- Hydraulics Equipment
- Control
- High-Speed Equipment
- High Temperature Equipment
- Servomechanisms
- Hot Gas Generators

FOR MORE INFORMATION contact Product Information Air Accessory Turbine Department Lynn, Mass. or mail the coupon.

HIGH RELIABILITY...
Another Important General Electric Product

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Schenectady 5, New York

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GENERAL  **ELECTRIC**

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ALINA HORIZONTAL DIAL COMPARATOR H-20

Indicator reads to .0001"

For high production—low tolerance applications!

The large 3 1/4" diameter dial indicator permits rapid, highly accurate readings because of widely spaced and easily visible graduations. The H-20 is equipped with the M-50 dial indicator that can also be furnished separately. This highly sensitive indicator is jewelled at critical wear points and has a range of .120"



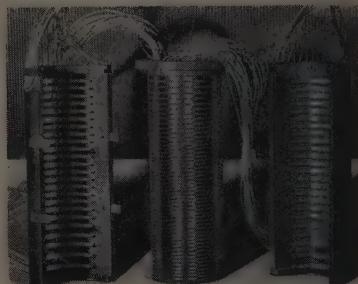
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ALINA CORPORATION

122 East Second Street, Mineola, L. I., N. Y.

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SLIP RING ASSEMBLY
for power and signal use



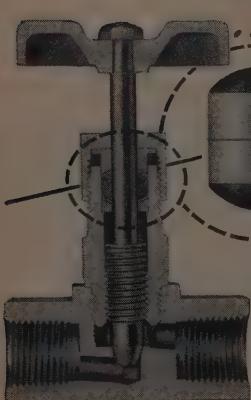
This 48-ring assembly can be applied with rate tables, missile flight simulators, and radar missile tracking units. Current range for the unit (smallest to largest rings) is 1 to 20 amps. The units have been subjected to a 2,000 V, 60 C hypot test between ring for 10 seconds, says Superior Carbon Products, Inc., Dept. S/A, 9115 George Ave., Cleveland 5, Ohio.

The assembly is made with fine gold-plated silver rings. Brush contacts are silver graphite. Ring diameters are insulated with Teflon. Ring diameter, including brush block, is 6 1/2 in. Height is 15 in. Slip ring assemblies for commercial use are also available.

Write in No. 338 on Reader Service Card

"...yet we have IMPROVED it"

The Marsh Stainless Steel Needle Valve could have gone right on being the finest in its field...yet we have improved it



...with fabulous
"TEFLON"
packing

Note the "close-up." The Marsh Marpak packing system, originated in the Marsh Needle Valve, was one of the factors that has enabled it to stand up and work right under pressures up to 10,000 psi.

Now "Teflon" is used in this packing system—the miracle material of almost incredible toughness, resilience and non-adhesive properties...properties that are not impaired by the most powerful of solvents, acids, or alkalies even at temperatures up to 500° F.

Net result: The guaranteed application-range (up to 10,000 psi) is now effective at any temperature up to 500° F. (In other makes, permissible temperature decreases as pressure increases.)

Marsh Marpak Teflon Packing System is standard in Marsh 416 Stainless Steel Needle Throttling Valves. Ask for facts.

MARSH Needle Valve in 416

stainless steel throughout
Now with "Teflon" Packing

MARSH INSTRUMENT CO. Sales Affiliate of Jas. P. Marsh Corp., Dept. 43, Skokie, Ill.
Marsh Instrument and Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta
Houston Branch Plant: 1121 Rothwell St., Sect. 15, Houston, Texas

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Minute Giants . . .

B.M.B. Miniature Bearings to the highest precision limits, are made specially for Space craft, missile or ground support instrumentation.

Stainless Steel for servo applications—B.M.B. have supplied miniature bearings to the American market for the past ten years.

Miniaturization plus reliability equals faultless functioning equals B.M.B. Miniature Bearings.

AGENTS:

David R. Grossman Co., 155 East 44th Street, New York 17, N. Y. U. S. A.

Engis Equipment Co., 431 South Dearborn Street, Chicago, Illinois, U. S. A.

Manufacturing Associates, 1416 Westwood Blvd., Los Angeles 24, California, U. S. A.

BRITISH MANUFACTURED BEARINGS CO., LTD.

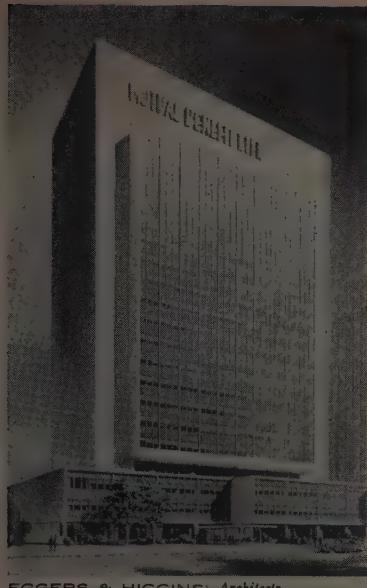
Sole Selling Agents:

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SPACE/AERONAUTICS



The Hand with the

Golden Touch

uses A.W.Faber-CASTELL

with **BLACK GOLD**

Graphite



There are two kinds of ability—creative and interpretive. Both are responsible for our march of progress. Both get an important "assist" from CASTELL with the Black Gold Graphite.

Whatever your status, CASTELL will give your eager, sensitive fingers the "golden touch" by transforming your grey matter into black matter on paper or cloth.

CASTELL is your always-reliable drawing tool, made with the world's finest natural graphite that tests out at more than 99% pure carbon. It contains no smudgy, smeary foreign substance to give the false illusion of black.

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Choose from: #9000 CASTELL Pencil. #9007 CASTELL with Eraser. #9800SG LOCKTITE TEL-A-GRADE Holder with new functional spiral grip and degree indicating device. #9030 CASTELL Refill Lead matching #9000 pencil in quality and grading, packed in reusable plastic tube with gold cap. Other styles and colors of pencils, holders and refill leads.

Castell Leads and Pencils draw on all surfaces, including Mylar-based polyester drafting films. Give perfect lines, easy to erase—excellent reproduction.

BACKED BY NEARLY 200 YEARS UNINTERRUPTED
MANUFACTURING EXPERIENCE — SINCE 1761

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Oster[®]

*to
the
Outside*

MISSILE QUALITY SERVOS

For trouble-free systems, missile designers specify Oster reliability. Choose from the Complete Line for Missile, Aircraft & Ground Support Applications.

- Sizes 8, 10, 11, 15, 18, 23, 29 in 400 cycle. Sizes 15, 18, 23 in 60 cycle.
- -55° to $+125^{\circ}\text{C}$ temperature range. Higher temperature servos available for special applications.
- Meet MIL-E-5272A & MIL-E-5400.
- Available with leads & terminals to your requirement.
- Immediate delivery from stock of many types in sample quantities.



NEW 24-page SERVO MOTORS CATALOG No. 5000

Lists 40 basic servo types for military, scientific and industrial applications. Write for your free copy on company letterhead today.

OTHER PRODUCTS INCLUDE:

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Engineers For Advanced Projects:

Interesting, varied work on designing transistor circuits
and servo mechanisms.

Contact Mr. Robert Burns, Personnel Manager, in confidence.

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Jet Miracle by Boeing 707 Protective Coatings by Amchem Alodine!

At Boeing's Seattle and Renton plants giant dipping tanks are utilized to treat unpainted portions of 707 fuselages and engine pods with Amchem Alodine, the superb chemical conversion coating. The amorphous chromate coating imparted to aluminum by Alodine endows this strong light metal with corrosion resistance and adhesion characteristics superior to other chemical treatments. This superiority of Amchem Alodine is needed to withstand the rigorous environments experienced in jet flight.

Alodizing with Alodine is the fastest method of treating aluminum parts uniformly. Savings are realized through reduced costs of electrical power, labor and processing time, fewer rejects. And Amchem technical specialists are always available to render assistance in determining initial requirements, recommending proper equipment, training personnel and following through on quality control.

Follow the industry leaders who specify Alodized with Alodine for a finer end product.

Write for Bulletin 1424B describing specific applications of Amchem Alodine. Contains handy Selection Chart to help you choose the Alodine type suited to your needs.



ALODINE

another chemical development of
Amchem Products, Inc., Ambler 00, Pa.
(Formerly American Chemical Paint Co.)

Detroit, Mich., St. Joseph, Mo., Niles, Calif., Windsor, Ont. • Amchem and Alodine are registered trademarks of Amchem Products, Inc.

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data preview

FUEL OXIDIZER—Perchloryl fluoride, said to be the first fuel oxidizer specifically designed for rocketry, is discussed in a 24-page booklet available from Pennsalt Chemicals Corp., Dept. S/A, 3 Penn Center, Philadelphia 2, Pa. The oxidizer, which freezes at -146 deg F and boils at -52 deg F, features excellent storability, stability and performance characteristics.

Write in No. 339 on Reader Service Card

ALKALI METALS—Up-to-date facts and figures on lithium and other alkali metals have been compiled in a 24-page brochure with six charts and 14 illustrations by Montgary Explorations Ltd., Dept. S/A, Toronto, Ont., Canada. Current prices, principal uses and producers are described including applications only recently announced.

Write in No. 340 on Reader Service Card

FACILITIES REPORT—A 52-page brochure detailing its history, organization and work in hydraulic, pneumatic, electronic and mechanical components has been released by Sargent Engineering Corp., Dept. S/A, 2533 E. 56th St., Huntington Park, Calif. The report covers research, design, qualification, and manufacturing facilities.

Write in No. 341 on Reader Service Card

METER MOUNTING—The protection of sensitive instruments against shock and vibration by means of a bonded rubber meter mounting is described in a four-page bulletin available from Lord Mfg. Co., Dept. AvAge, 1635 W. 12th St., Erie, Pa. Bulletin 601 discusses design features, advantages and performance of the patented mountings and contains photographs of typical installations.

Write in No. 342 on Reader Service Card

PRESSURE TRANSMITTERS—Bulletins P-58176-GP and P-5701, which present information on the Models 176-GP and 176 pressure transmitters, respectively, have been prepared by Taber Instrument Corp., Dept. AvAge, 111 Goundry St., North Tonawanda, N.Y. The stainless steel units, which are available in a variety of ranges from zero to 300 psig to zero to 10,000 psig, are identical except for the gas-proof electrical connection of the 176-GP.

Write in No. 344 on Reader Service Card

SWITCHES—The ESCO line of rotary multiple switches is described in a 20-page catalog (in standard file or miniature size), available from Electro Switch Corp., Dept. S/A, Weymouth 88, Mass. Information on solenoid-operated, instrument and control switches is included, along with details on a trigger-switch.

Write in No. 345 on Reader Service Card

SOLENOID VALVES—Information on three-way solenoid valves for use with medium-size cylinders is available from Skinner Electric Valve Div., Dept. AvAge, 105 Edgewood Ave., New Britain, Conn. The first unit in the A Series is a normally-closed valve with a pressure rating of 125 psi, which may be used with oil, air, inert gases, and like media.

Write in No. 346 on Reader Service Card

LOX PRODUCTION—A 16-page catalog on rectification plants for the production of oxygen and nitrogen in liquid or gaseous form has been issued by Superior Air Products Co., Dept. AvAge, 132 Malvern St., Newark 5, N.J. Equipment described includes station pumps with vaporizers, and storage and converter tanks for liquid oxygen, hydrogen, and argon.

Write in No. 347 on Reader Service Card

TEFLON—Bulletin GST-58 is an eight-page brochure giving mechanical, electrical and chemical properties of C-D-F Glass Supported Teflon in the various forms and is available from Continental-Diamond Fibre Corp., Dept. AvAge, Newark 107, Del. The bulletin also gives widths, nominal thicknesses, and thickness tolerances for standard and special grades of glass-supported Teflon tapes, laminates, metal clads, and fabricated parts.

Write in No. 348 on Reader Service Card

INSULATION—An extremely low-conductivity molded insulation expressly developed for rockets, missiles and aircraft engines is described in a 12-page brochure by Johns-Manville, Dept. AvAge, 22 E. 40th St., New York 16, N.Y. Min-K, which may be used for duct insulation, jet engine shrouds, panels, and wrap-around blankets, is easy to machine, saw and cut, and it can be molded to special shapes with close dimensional tolerances.

Write in No. 349 on Reader Service Card

TRANSDUCER—The Type MA rectilinear transducer, engineered for critical ac measurement and servo applications in missile, aircraft and industrial systems, is described in a two-page technical bulletin by Crescent Engineering and Research Co., Dept. S/A, 5440 N. Peck Rd., El Monte, Calif. Ratio of sensitivity to null is 100 to 1.

Write in No. 350 on Reader Service Card

CORROSION-RESISTANT PLASTIC—Bulletin Ad-152, published by United States Gasket Co., Plastics Div., Garlock Packing Co., Dept. AvAge, Palmyra, N.Y., describes its corrosion-resistant Kel-F Plastic Laminate which can be applied to any surface having almost any contour. The properties of the plastic lining material are outlined and the advantages and methods of applications are explained.

Write in No. 351 on Reader Service Card

FASTENERS & SMALL PARTS—Catalog No. 106 is a new condensed handbook on the design and use of such cold headed specialties as rivets, nails, screws, and other fasteners and small parts published by John Hassall, Inc., Dept. AvAge, Westbury, L.I., N.Y. Data includes cost and design features plus information on metals and finishes.

Write in No. 352 on Reader Service Card

DATA PROCESSING—Bulletin 3017 is a six-page publication fully describing the Model 210 data processing system made by Beckman Systems Div., Dept. S/A, Anaheim, Calif. The system, which may be used for wind tunnel and engine test stand data, receives up to 1000 input signals at high speed, converts signals to digits, and puts information on magnetic tape in a format suitable for any computer.

Write in No. 353 on Reader Service Card

TORQUE MOTORS—A fact sheet listing specifications for a series of torque motors of graduated performance characteristics has been prepared by American Measurement & Control, Inc., Dept. S/A, 240 Calvary St., Waltham 54, Mass. Miniature, high-performance units suitable for extreme environmental conditions are among available units, which are used primarily as hydraulic servo-valve actuators but are useful in other applications.

Write in No. 354 on Reader Service Card

more on page 269

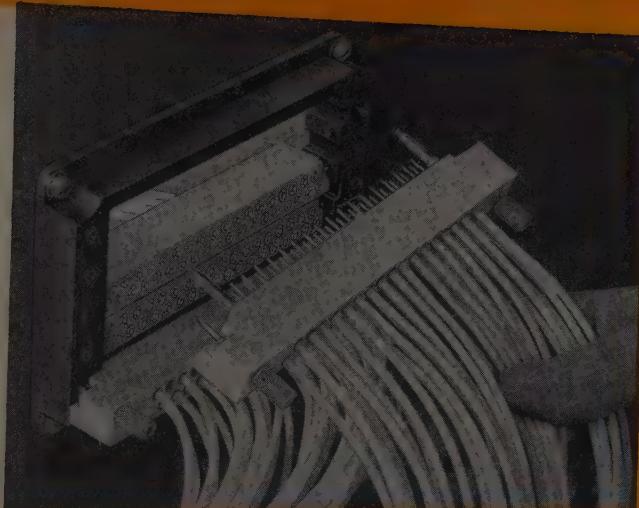


feed-thru,
multiple
insert

HYFEN® connector

with crimp-type,
snap-locked
contacts

Makes possible
the design of
lighter and more
compact equip-
ment. Each insert
holds 35 contacts.
Frames available
for 5 or 8 inserts.



crimp-type

MODULAR ELECTRICAL CONNECTORS

IN 3 NEW BASIC TYPES

Modular units by Burndy provide versatile, rapid and reliable answers to the problem of connecting a multiplicity of wires in relatively limited spaces. Crimped contacts—installed with any of several hand, pneumatic, semi-automatic or automatic tools—can be removed, re-inserted or replaced, providing the most complete flexibility in the connector field. Computers, ground-based radar, missile ground controls, and instrumentation are typical applications for Burndy modular connectors.

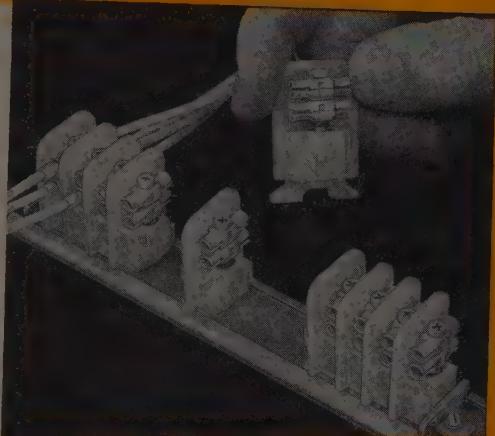
quick-disconnect
or permanently
connected

MODULOK®

terminal block

with snap-in,
spring-loaded
contacts

True versatility in a
terminal block. 30
modules (2 or 4 tier)
per foot. Twist of a
screwdriver transforms
quick-disconnect con-
tacts to permanent
connections.



*Trade Mark

crimp-type,
solid-shank

STAPIN®

**taper pin
contacts**

Another
Burndy contri-
bution to the
modular con-
cept of assem-
bling standard
units to pro-
vide custom-
fitted end
products.



For complete information, write: OMATON DIVISION

BURNDY

Norwalk, Connect. In Europe: Antwerp, Belgium 58-24 Toronto, Canada

Write in No. 176 on Reader Service Card at start of Product Preview Section

NEW HIGHER PERFORMANCE FOR FORMCHROME* SPRAGS

On over-running clutch applications, Formsprag clutches have always provided greatest torque capacity for size and weight, no measurable backlash, extreme precision and long trouble-free life. Now! With newly designed Formchrome sprags, the best over-running clutches provide users with even higher performance.

Here's why! The new Formchrome sprags are made of hardened high carbon alloy steel with chromium diffused into the surface to form a chromium-carbide alloy. Thus, the sprag is corrosion resistant, and has high hardness and abrasion resistance similar to tungsten carbides. Result—sprag geometry is retained over a longer period and clutches can be used on higher over-running speeds. The Formchrome sprag is exclusive with Formsprag—no other clutch manufacturer can offer you its performance advantages.

Typical of the higher performance users can now receive from Formsprag clutches is this specific example: A Formsprag clutch using

Formchrome sprags was installed in the reaction member of a torque converter and a competitive clutch in another. The competitive clutch showed excessive wear after the equivalent of one year of operation. The Formsprag clutch was run 50% longer and still showed only negligible wear.

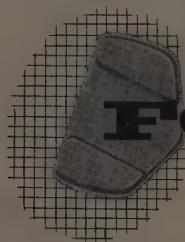
There is a Formsprag clutch for every application—from business machines to aircraft. Standard clutches cover a wide range of uses and are described in the Formsprag Catalog . . . send for your free copy. However, to meet unusual requirements, Formsprag engineers will modify a standard clutch or design a special—send your application details.

FORMSPRAG COMPANY
23597 Hoover Road, Dept. 102
Warren (Detroit), Michigan

In Canada: Renold Chains Canada, Limited
In United Kingdom: Renold Chains, Limited
Distributors in Principal Cities



*Formchrome sprags are produced under a patented process. The use of this process in the manufacture of over-running clutches is exclusive with Formsprag.



FORMSPRAG CLUTCHES

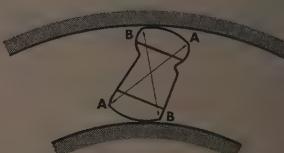
World's Largest Exclusive Manufacturer of Over-running Clutches

TYPICAL APPLICATIONS WHERE FORMCHROME SPRAGS HAVE PROVEN SUPERIOR PERFORMANCE

1. Used in operating submarine missile (Regulus II), Formsprag clutch allows alternator to over-run the hydraulic driving mechanism.
2. Backstop clutch on belt conveyor handling bauxite ore is subjected to higher over-running speed, extreme abrasive dust and hot weather—has been in operation a year.
3. Starter clutch for aircraft ground support system allows high-speed gas turbine to over-run starter unit.

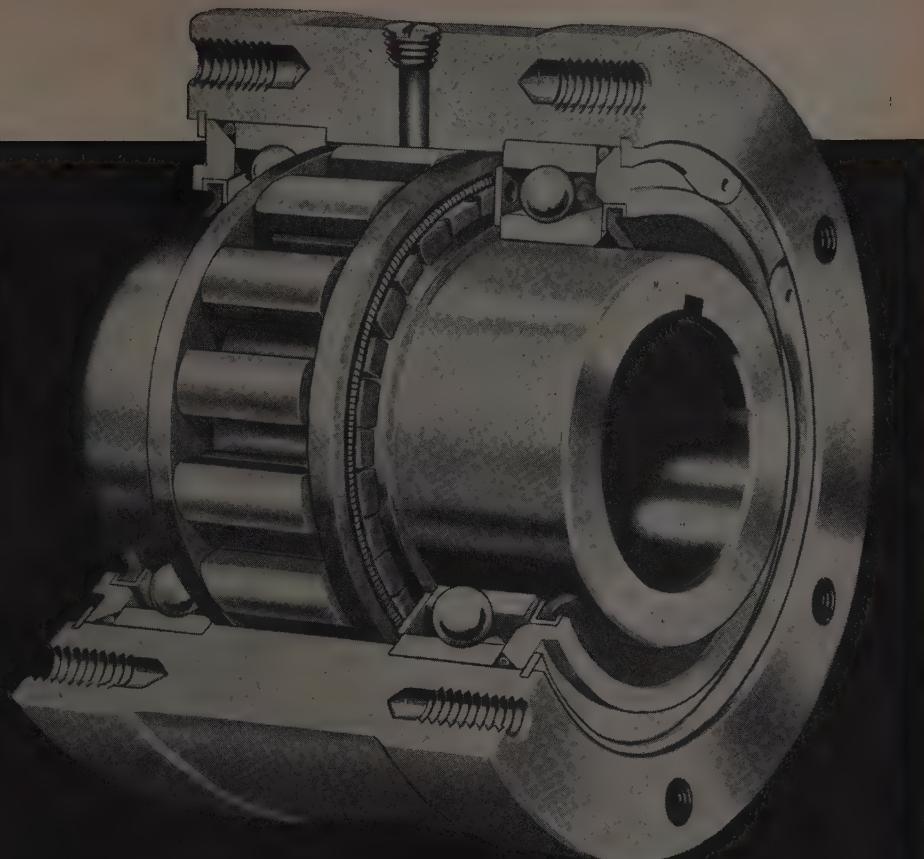
For additional information on how Formchrome sprags assure better performing clutches, write for technical paper "Formchrome Sprags".

HERE'S



The Formsprag clutch consists of a full complement of shaped sprags, or wedges, located between concentric inner and outer races. Power is transmitted from one race to the other by the wedging action of the sprags. Each sprag is so shaped that dimension AA is greater than BB. Rotation of one race in the "driving" direction causes the sprags to wedge, transmitting torque in full from one race to the other.

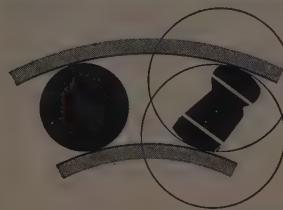
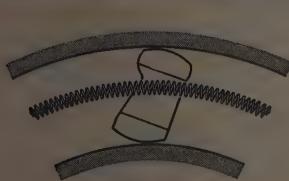
FORMSPRAG OVER-RUNNING CLUTCHES WITH



Micro photo showing chromium-carbide wear surface (1900 Vickers— $80 R_c$) of Formchrome sprags. Chromium is diffused into high-carbon alloy steel sprag (62Rc).

OVER-RUNNING • INDEXING BACKSTOPPING

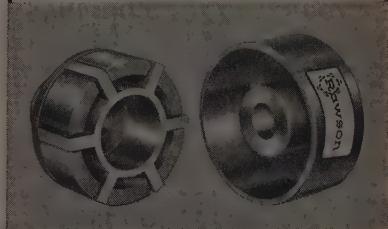
HOW IT WORKS



An expanding coil spring keeps the sprags in light contact with both inner and outer races. There is thus no lost motion, the driving torque being instantaneously transmitted between races. The Formsprag Clutch is so designed that it will transmit a greater torque in relation to its size and weight, than any other comparable type of clutch . . . specify Formsprag on over-running, back-stopping and indexing applications.

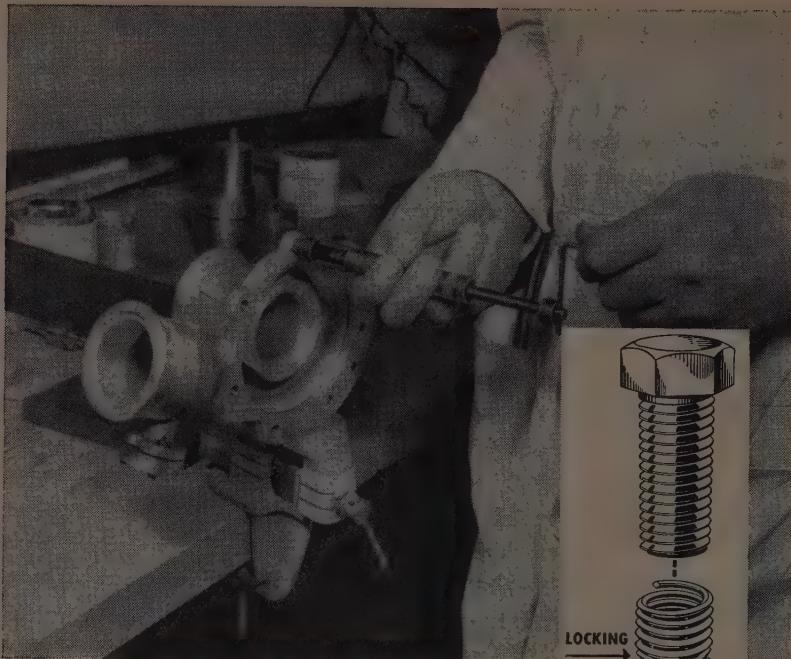
Forcing a ball or roller into a curved, wedged space is an old over-running clutch principle. The sprag is, in effect, a "roller" of increased diameter with greater contact surface in a given annular space. Formsprag Clutches engage at constantly changing contact points. Clutch life is prolonged and backlash eliminated. Also, with the inclined surfaces discarded, more sprags can be inserted to increase torque capacity.

RAWSON FOR NO-LOAD STARTS

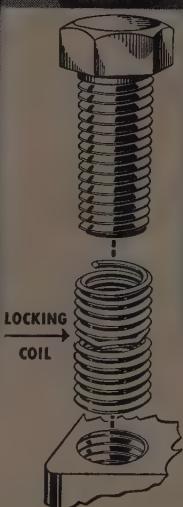


Specify Rawson Automatic Centrifugal Clutches and Clutch Couplings. They protect the prime mover, eliminate need for costly reduced voltage starting equipment, permit use of less expensive smaller motors to start high inertia loads. Completely automatic and entirely mechanical in operation, Rawson clutches provide full overload protection, never need adjustment. Write for the new Rawson Clutch Catalog now.

Write in No. 177 on Reader Service Card at start of Product Preview Section



Heli-Coil® Stainless Steel Screw-Lock Insert is easily wound into tapped hole in lightweight aluminum housing. Spring tension of the locking coil retains screw securely, meets military specifications for locking torque and vibration.



How Carrier Corporation Saves 40% in weight • 30% in assembly time ...with HELI-COIL® SCREW-LOCK INSERTS*

Use of aluminum lightens Carrier refrigeration system in Douglas DC-8 Jetliner

To reduce weight in the refrigeration system designed for air conditioning the giant Douglas DC-8 Jetliner, Carrier engineers used aluminum alloy compressor castings. To obtain maximum performance and reliability of threaded connections exposed to heat and vibration encountered at 600 mph, they selected the Heli-Coil stainless steel wire thread, *internal locking* Screw-LOCK Insert.

The results: design simplified, boss areas minimized, weight re-

duced as much as 40%, lock nuts and lock wiring eliminated. Now one man assembles the entire unit in 30% less time than before... and danger of thread failure and screw loosening has ended!

Manufacturers in every field are relying on one-piece, stainless steel Heli-Coil Screw-LOCK Inserts to meet torque and vibration specs... protect threads against wear, stripping, galling and corrosion... save costs, space and weight.

*Patented



HELI-COIL CORPORATION
DANBURY, CONNECTICUT

HELI-COIL CORPORATION 105 Shelter Rock Lane, Danbury, Connecticut
I'd like more information on Heli-Coil Screw-LOCK Inserts

NAME _____

TITLE _____

FIRM _____

ADDRESS _____

CITY _____

ZONE _____ STATE _____

1568

IN CANADA: W. R. WATKINS CO., Ltd., 41 Kipling Ave., S., Toronto 18, Ont.

Write in No. 178 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

BALL SCREWS—Technical information on ball screws, ball splines, and ball ways suited to the aircraft and related industries is available in an eight-page brochure issued by Beaver Precision Products, Inc., Dept. S/A, 651 N. Rochester Rd., Clawson, Mich. Cutaway drawings and photographs of a variety of these devices are included among the illustrations.

Write in No. 355 on Reader Service Card

NYLON BEARINGS—Form 209 is a comprehensive eight-page technical data bulletin and catalog on nylon bearings made by Thomson Industries, Inc., Dept. S/A, Manhasset, N.Y. Nyliners, which in production quantities are said to cost less than comparable bearings, are designed for snap-in installation and may be used without lubrication in many applications.

Write in No. 356 on Reader Service Card

ROTORS—Information on small, composite turbine rotors of brazed sheet metal construction that feature weight and cost savings is contained in Report 2085, by Stalker Development Co., Dept. S/A, 903 Woodside Ave., Essexville, Mich. Drawings are used to point up construction details of various rotor types.

Write in No. 357 on Reader Service Card

FLUID CONTROL—A folder on missile control systems for fuels, oils, oxidizers, and coolants has been prepared by Koehler Aircraft Products Co., Dept. S/A, 409 Leo St., Dayton, O. The publication covers several types of valves, as well as strainers and filters.

Write in No. 358 on Reader Service Card

SUBMINIATURE RELAYS—A broad range of over 325 subminiature relays meeting and excluding MIL-5757A, B&C and MIL-R-25018 (USAF) are described in a new 12-page, illustrated booklet issued by Industrial Electronic Products Div., RCA, Dept. S/A, Bldg. 15-1, Camden 2, N. J.

Write in No. 359 on Reader Service Card

INSULATION—Various type of glass fiber insulations, their description, product features, uses, and other pertinent details have been covered in Form WPD-13, an eight-page product design brochure available from L. O. F. Glass Fibers Co., Dept. S/A, 1810 Madison Ave., Toledo 1, O. Information on quartz micro-fibers for high-temperature insulation has also been included.

Write in No. 360 on Reader Service Card
more on page 274

NEW!

SMALL!

DELCO POWER TRANSISTOR

*Designed
for use
where space
and weight
are
restricting
factors*



MAXIMUM RATINGS		2N1172
Collector Diode Voltage		40 volts
Emitter Diode Voltage		20 volts
Collector Current		1.5 Amperes
Junction Temperature		95°C
TYPICAL CHARACTERISTICS (25°C)		
Typ. Collector Diode Current I_{C0} $V_{cb}=40$ volts		50 μ
Current Gain ($V_{ce}=-2$ volts, $I_c=100$ Ma)		70
Current Gain ($V_{ce}=-2$ volts, $I_c=1/2$ A)		30
Saturation Resistance		0.3 ohms
Cutoff Frequency (Common Emitter)		17 kc
Thermal Resistance		12° C/Watt

The 2N1172 is a medium power transistor offering dependable operation in a new range of applications where space and weight have been a problem.

It's a mighty mite with more punch in a smaller package. The 2N1172, excellent for output use or as a driver for a very high power transistor, has already proved especially effective in DC amplifiers, voltage regulators, and as a driver for a high power stage in servo or other amplifiers.

This PNP germanium transistor is housed in a modified version of the JEDEC 30 package with a diamond shaped base for improved thermal conduction. It dissipates up to 2 watts at a mounting base temperature of 70 degrees centigrade. Available now in volume production—write today for complete engineering data.

DELCO RADIO

Division of General Motors
Kokomo, Indiana

BRANCH OFFICES

Newark, New Jersey
1180 Raymond Boulevard
Tel: Mitchell 2-6165

Santa Monica, California
726 Santa Monica Boulevard
Tel: Exbrook 3-1465

Write in No. 179 on Reader Service Card at start of Product Preview Section



Mission: MAN IN SPACE

Filter Application: PROTECT HYDRAULIC CONTROLS

Filter: PUROLATOR

A malfunction in the lines of the hydraulic and pneumatic controls of the X-15 could send it off its programmed trajectory . . . alter the angle of re-entry . . . cause deviation from the ballistic arc.

Purolator filters are on the X-15 to protect the control systems. Three new filtering applications were worked out for North American Aviation, designers and builders of the X-15, by Purolator engineers to meet the space-age requirements of the manned missile.

Filters for crucial aircraft and missile requirements are a specialty at Purolator . . . and every application is considered as crucial as those on the X-15. Draw on Purolator's experience to help you handle your filtration requirements. A phone call or a descriptive letter, with plans or blueprints, will receive prompt attention.

Write in No. 180 on Reader Service Card at start of Product Preview Section

Filtration For Every Known Fluid

PUROLATOR
PRODUCTS, INC.

Rahway, New Jersey and Toronto, Ontario, Canada

VALUE ANALYSIS where it really counts ... during design!



C/R Shaft Type Oil Seal



C/R Standard End Face Seal



C/R Sirvane Diaphragm



C/R Sirvis Molded Cup



C/R Rawhide Beveled Gear

Here's an expert at work, saving you money at the right time — during design. Like all C/R sales engineers, he's an experienced, well-trained representative whose knowledge springs from a solid engineering background. His ability to sit down with you during the design phase will help develop the most efficient and economical solutions to your problems.

For example, he will often suggest design modi-

fications that may save substantial production costs. Again, he will advise against specifications or seal types which he knows from experience will lead to service problems and user dissatisfaction. His personal "value analysis" of your fluid sealing problems, backed by the quality of these Chicago Rawhide products, can save you money. Welcome him when he calls to see you.

CHICAGO RAWHIDE MANUFACTURING COMPANY

1293 ELSTON AVENUE • CHICAGO 23, ILLINOIS

Offices in 55 principal cities. See your telephone book.

In Canada: Manufactured and Distributed by Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario.

Export Sales: Geon International Corp., Great Neck, New York

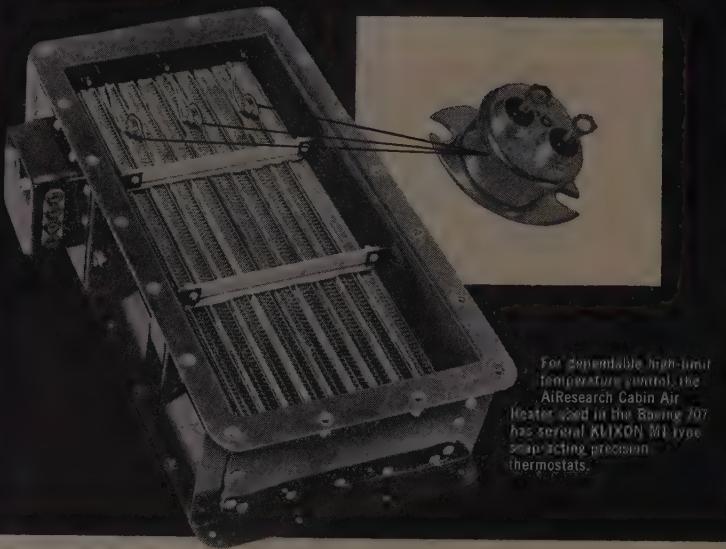


CHICAGO RAWHIDE

Write in No. 181 on Reader Service Card at start of Product Preview Section

Klixon Precision Thermostats

HELP ASSURE DEPENDABLE, SAFE OPERATION OF MANY BOEING 707 COMPONENTS



For dependable high-limit temperature control, the AiResearch Cabin Air Heater used in the Boeing 707 has several Klixon M1 type snap-acting precision thermostats.



Boeing 707 Jet Airliner
now in regular passenger service.

For example, on the cabin air heaters produced by AiResearch Manufacturing Division of The Garrett Corporation, Klixon Precision Thermostats assure positive temperature protection . . .

contributing to heater safety and dependability. These heaters are lightweight units which fit into the 707's main cabin air-conditioning ducts where they warm incoming air to proper temperature. The thermostats shut off the main power source to the heaters as a safety precaution in the event temperature exceeds the limit value.

Klixon snap-acting controls are ideal for applications of this type — for several important reasons. They are small in size and light in weight; they respond to temperature change quickly and with accurate repeat performance; they have ample capacity to carry electrical loads as required; and their calibrations stand up in the face of severe environmental conditions.

Let qualified Spencer engineers assist you, too, with your temperature control requirements. They will be pleased to study your application and, if a standard Klixon Precision Control is not available for it, they can recommend adaptations to operate or protect your particular equipment. Write today for the Klixon Precision Thermostat Catalog. Choose Klixon Controls with confidence.

Western manufacturers — refer inquiries to Metals & Controls Corporation, Southern California Office...232 North Lake Avenue, Pasadena, California . . . Telephone Ryan 1-4288.

METALS & CONTROLS

Spencer Division



CORPORATION

3705 Forest St., Attleboro, Mass.

KLIXON

Write in No. 182 on Reader Service Card at start of Product Preview Section

PLASTIC FABRICATING
Matched die molding, vacuum bag molding, contact molding and tube wrapping of Fiberglas reinforced parts are covered in detail in a brochure available from Atlas Plastics, Inc., Dept. S/A, 690 Seneca St., Buffalo 10, N. Y. The information on plastic fabricating techniques also discusses pre-mix molding and the use of epoxy resins for tooling.

Write in No. 361 on Reader Service Card

ROTARY SWITCH—The Model BD2E Ledex subminiature rotary selector switch, which is useful in stepping, programming, homing and other applications, is the subject of Bulletins 558S2 and 558ST2, available from G. H. Leland, Inc., Dept. S/A, 123 Webster St., Dayton 2, O. The first provides specifications on one-, two-, three- and four-wafer designs, plus the hermetically-sealed type, and the second is devoted to the four-wafer design.

Write in No. 362 on Reader Service Card

FOAMS—Brochures on rigid, semi-rigid and flexible Stafoam polyurethanes are available from American Latex Products Corp., Dept. S/A, 3341 W. El Segundo Blvd., Hawthorne, Calif. The materials are now being used in the aviation, instrumentation, missile and other fields for vibration damping, insulation, structural strength, cushioning and flotation.

Write in No. 363 on Reader Service Card

BRAZED COMPONENTS — "Aircraft, Missile, and Nuclear Brazed Components," which describes facilities for the design and fabrication of experimental prototype and production quantities of highly engineered components, has been issued by Aircraft Components Div., Ferrotherm Co., Dept. S/A, 1851 E. 65th St., Cleveland 3, O. The six-page facility listing covers the latest silver alloy and nickel alloy brazing techniques.

Write in No. 364 on Reader Service Card

NICKEL ALLOYS — Two new nickel-base alloys are the subjects of publications recently issued by Haynes Stellite Co., Dept. S/A, 420 Lexington Ave., New York 17, N.Y. Hastalloy Alloy B, which combines excellent corrosion resistance with good strength at high temperatures, is covered in a 12-page booklet. A folder details the physical, chemical and mechanical properties of Alloy D, a cast nickel-base alloy with outstanding resistance to corrosion from sulphuric acid at all concentrations and temperatures.

Write in No. 365 on Reader Service Card

more on page 278

A Logical Deduction

Because ordinary magnetically-regulated power supplies are too sluggish to handle load and line transients,

Because NJE refused to be satisfied with such performance, and developed, back in 1956, a fundamentally superior circuit,

Because this thoroughly proven circuit uses the speed and power-gain of a transistor amplifier to force rapid response from the magnetic amplifier,

Because the transistors are never in the power path, but handle low-level signals only,

Because this transistor-magnetic — "TRM" — circuit retains the reliability and economy of magnetically-regulated supplies, but greatly improves speed of response (15 millisec. typical), widens operating range (8:1 typical) and tightens regulation (0.1% typical),

Because TRM supplies can be "zero-lagged" against line and load transients,

Because *It follows that* NJE TRM is your best buy in a magnetically-regulated power supply!

QED...choose NJE



TRM-40-30
5-40 volts
0-30 amperes

Write for complete catalog

MODEL NUMBER	OUTPUT RANGE	
	VOLTS	AMPERES
TRM-28-30	24-32	0-30
TRM-28-60	24-32	0-60
TRM-28-120	24-32	0-120
TRM-40-15	5-40	0-15
TRM-40-30	5-40	0-30
TRM-40-60	5-40	0-60
TRM-40-120	5-40	0-120
TRM-80-7.5	10-80	0-7.5
TRM-80-15	10-80	0-15
TRM-80-30	10-80	0-30
TRM-80-50	10-80	0-60
TRM-160-7.5	20-160	0-7.5
TRM-160-15	20-160	0-15
TRM-160-30	20-160	0-30



N J E CORPORATION

345 Carnegie Avenue, Kenilworth, New Jersey

CH 1-1500 TWX - ROSELLE, N.J. 51 FAX - FFP



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The Case For 105mm Miniaturization of Engineering Drawings

Micro-Master® 105mm, supplied by K&E,
is the only system designed specifically
for engineering drawings

Micro-Master 105mm offers the general advantages you expect of any miniaturization system — space savings, protection of costly originals, and ready distribution of duplicates. But Micro-Master provides these advantages *without* over-mechanization. A 105mm negative — measuring a generous 4 by 6 inches — is large enough to be located easily and read quickly without elaborate scanning and sorting devices. In addition, a national network of K&E dealers stands ready to provide the 105mm service you need.

A Complete System from Film to Print

Micro-Master is a totally integrated system for photographing, film processing and final reproduction or projection printing. Completely precision-engineered — from optics through films, papers and chemicals — the system provides extremely sharp, high-contrast "thin" negatives that furnish high-quality, absolutely uniform prints. Critical alignment of camera and projector, and special vacuum frames which hold materials absolutely flat, are typical of the optical and mechanical features that make the Micro-Master system an engineering aid of highest quality.

No Distortion In Blow-Backs

Maximum reduction or enlargement for Micro-Master 105mm is 10 diameters — not up to 30 diameters as with smaller negatives. Thus, when drawings as large as 40 by 60 inches are reduced or re-

enlarged, they retain a clear, sharp quality — even in the corners. There is no distortion or loss of detail, for all Micro-Master reproductions are made inside the photographic "quality barrier" of 10 diameters. Projection prints can be made on inexpensive paper as well as on cloth or film.

Like-New Prints from Worn Originals

Old originals can be restored, too — even when badly damaged. The Micro-Master process uses *reflected* rather than transmitted light. Thus, detail which has been lost through light absorption — due to dirt or discoloration — will "snap back" on the film — giving you clean prints with clear backgrounds and sharp black lines equal to ink lines. The large negative size makes it easy to see and eliminate unwanted areas by "opaquing out." Any small paint brush can be used for this purpose.

Easy to Read... Always Accessible

You can read almost every detail on a 105mm negative just by holding it up to a window or other light source. Table viewers are recommended for close study, but are *not necessary* in the "search and selection" phase. In a large plant or office, engineers can find and consult from 105mm negatives without waiting for search and delivery of originals, and without having to blow back tiny reductions to a readable size. Engineers or technicians at branch

plants, warehouses or field installations can maintain compact, complete files of project information — accessible at any time without special equipment.

Easy to File, Easy to Mail

Micro-Master is a miniaturization system providing *individual* negatives that meet archival requirements. Each negative is kept in its own 5" by 8" envelope. There is ample space on the envelope for large, legible identification coding and other information. Over 12,000 drawings can be stored in a standard 5" by 8" card file cabinet. No complicated cross-indexing is needed, for negatives of original drawings and all subsequent revisions can be grouped in the same file, ready for immediate reference. The absence of sorting devices eliminates scratches and other film damage resulting from excessive mechanical handling.

See Your K&E Dealer for Information, Equipment, Service

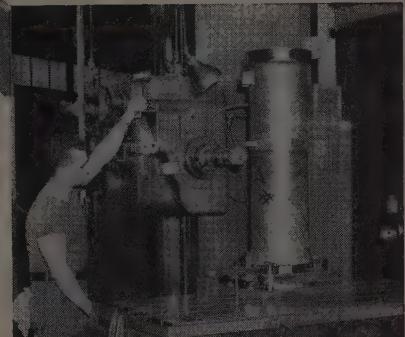
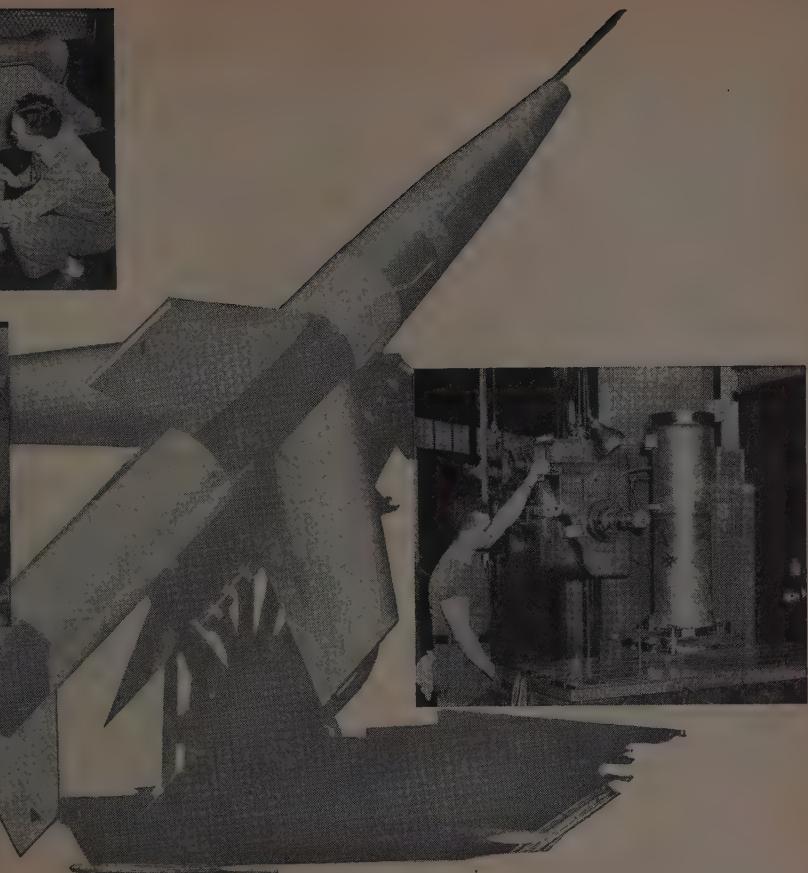
A camera, projector, three types of viewers, and all necessary printing accessories are available with the Micro-Master system, and all equipment can be obtained through your local K&E distributor. He can also furnish 105mm reductions and enlargements of your drawings as a service. For complete information, call your K&E dealer, or write to Keuffel & Esser Co., Dept. AA-5, 300 Adams St., Hoboken, N. J.



KEUFFEL & ESSER CO.

NEW YORK • HOBOKEN, N. J. • DETROIT • CHICAGO • MILWAUKEE • ST. LOUIS • DALLAS • SAN FRANCISCO • LOS ANGELES • SEATTLE • MONTREAL

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Missiles destined to be on target are built with PARISH precision

The U.S. Army's missile . . . La Crosse . . . is designed to kill in a single shot. That's why Martin engineers insist on the most rigorous specifications and why Parish was selected as subcontractor for the engine metal parts assembly.

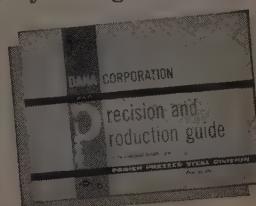
Precision . . . for absolutely controlled flight . . . is built into every part of the Parish assembly. Balance is critical and the weight of the entire assembly cannot vary more than $\frac{1}{4}$ of 1% of design weight. Add another factor . . . complete interchangeability . . . and you'll

see why Parish is one of the select few subcontractors regularly mass producing for the missile industry.

Parish has the experienced men and the precision tools for still another missile contract. Why not insure performance by calling Parish today?

WRITE TODAY . . .

For free booklet describing Parish facilities and equipment that can help cut costs for you.



● **DANA PRODUCTS:** Transmissions • Universal Joints • Propeller Shafts • Axles • Torque Converters • Gear Boxes • Power Take-offs • Power Take-off Joints • Rail Car Drives • Railway Generator Drives • Stampings • Spicer and Auburn Clutches • Parish Frames • Spicer Frames • Forgings

P

PARISH **PRESSED STEEL**

DANA Division of Dana Corporation Reading, Penna.

Write in No. 185 on Reader Service Card at start of Product Preview Section

Flight Data and Control Engineers

Cross new frontiers in system electronics at The Garrett Corporation.

High-level assignments in the design and development of system electronics are available for engineers in the following specialties:

1. ELECTRONIC AND FLIGHT DATA SYSTEMS AND CONTROLS

A wide choice of opportunities exists for creative R&D engineers having specialized experience with control devices such as: transducers, flight data computers, Mach sensors, servo-mechanisms, circuit and analog computer designs utilizing transistors, magamps and vacuum tubes.

2. SERVO-MECHANISMS AND ELECTRO-MAGNETICS

Requires engineers with experience or academic training in the advanced design, development and application of magamp inductors and transformers.

3. FLIGHT INSTRUMENTS AND TRANSDUCERS

1) DESIGN ANALYSIS Requires engineers capable of performance analysis throughout preliminary design with ability to prepare and coordinate related proposals.

2) DEVELOPMENT Requires engineers skilled with the analysis and synthesis of dynamic systems including design of miniature mechanisms in which low friction freedom from vibration effects and compensation of thermo expansion are important.

4. PROPOSAL AND QUALTEST ENGINEER

For specification review, proposal and qualtest analysis and report writing assignments. Three years electronic, electrical or mechanical experience required.

Forward resume to:

Mr. G. D. Bradley

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9851 S. Sepulveda Blvd.
Los Angeles 45, Calif.

DIVISIONS:

AiResearch Manufacturing—Los Angeles
AiResearch Manufacturing—Phoenix
AiResearch Industrial
Air Cruisers—Airsupply
Aero Engineering
AiResearch Aviation Service

DATA PREVIEW

STEEL TUBING—A new general catalog, CS-58, describing carbon & alloy seamless steel tubing in mechanical, aircraft mechanical, airframe quality and pressure grades has been issued by Ohio Seamless Tube Div., Copperweld Steel Co., Dept. AvAge, Shelby, Ohio. The new issue describes electric-resistance welded steel tubing, carbon steels, and fabricating and forging of steel tubing also.

Write in No. 366 on Reader Service Card

ROTARY SWITCH—Details of a new miniature, high-speed, motor-driven rotary switch for sampling and telemetering airborne applications are presented in a data sheet available from Instrument Development Laboratories, Inc., Dept. AvAge, 67 Mechanic St., Attleboro, Mass. A motor-within-commutator design is among the features discussed.

Write in No. 367 on Reader Service Card

SYNCHROS—A 20-page catalog has been issued to describe the synchros, precision computing resolvers, linear transformers, servo motors, and motor generators made by Clifton Precision Products Co., Inc., Dept. AvAge, 9014 W. Chester Pike, Upper Darby, Pa. Detailed tables provide the electrical and mechanical characteristics for an entire range of synchros.

Write in No. 368 on Reader Service Card

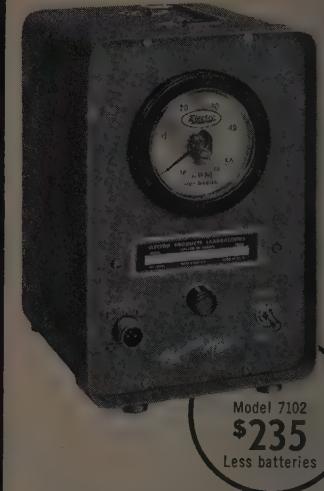
PULL TOOLS—A new eight-page illustrated two-color catalog, Form 8-420, describing its line of standard hydraulic pull tools for fastener installation is now available from Huck Mfg. Co., Dept. S/A, 2480 Bellevue Ave., Detroit 7, Mich. Characteristics of the three basic hydraulic units and a listing of the fasteners installed by each tool are included.

Write in No. 369 on Reader Service Card

RIVETS—A 16-page catalog and three bulletins describing applications of drive-pin blind rivets are included in a comprehensive data file offered by Deutsch Fastener Corp., Dept. S/A, P. O. Box 61072, Los Angeles 61, Calif. The illustrated, two-color catalog presents technical data, applications, dimensions and weights for stainless steel rivets. The first bulletin provides a table for designers to use in determining the lightest combination of fasteners. The second bulletin is an 11-page fatigue evaluation of blind rivets prepared by the engineering research laboratory of a major aircraft company. The third is a 23-page report with tables devoted to rivet allowables.

Write in No. 370 on Reader Service Card
more on page 282

Battery or AC Operation



Transistorized tachometer measures speed without physical "loading"

New portable ELECTRO-TACH tachometer releases your expensive electronic counters for other uses. Weston 250° meter movement guarantees speed readings accurate to 1% of full scale. Frequency-sensitive circuit simplifies application of magnetic pickups. Operates with 3010-AN and other ELECTRO Magnetic Pickups.

Standard Speed Ranges Available

Model	RPM	Gear needed
7101	0-2,000	60-tooth
7102	0-5,000	60-tooth
7103	0-10,000	30-tooth

7120 series for special over/under speed control

Write for new Bulletin ET-7100

Electro
ELECTRONIC EQUIPMENT

ELECTRO PRODUCTS LABORATORIES

Sensing Elements for Control Counting Speed and Displacement Measurements

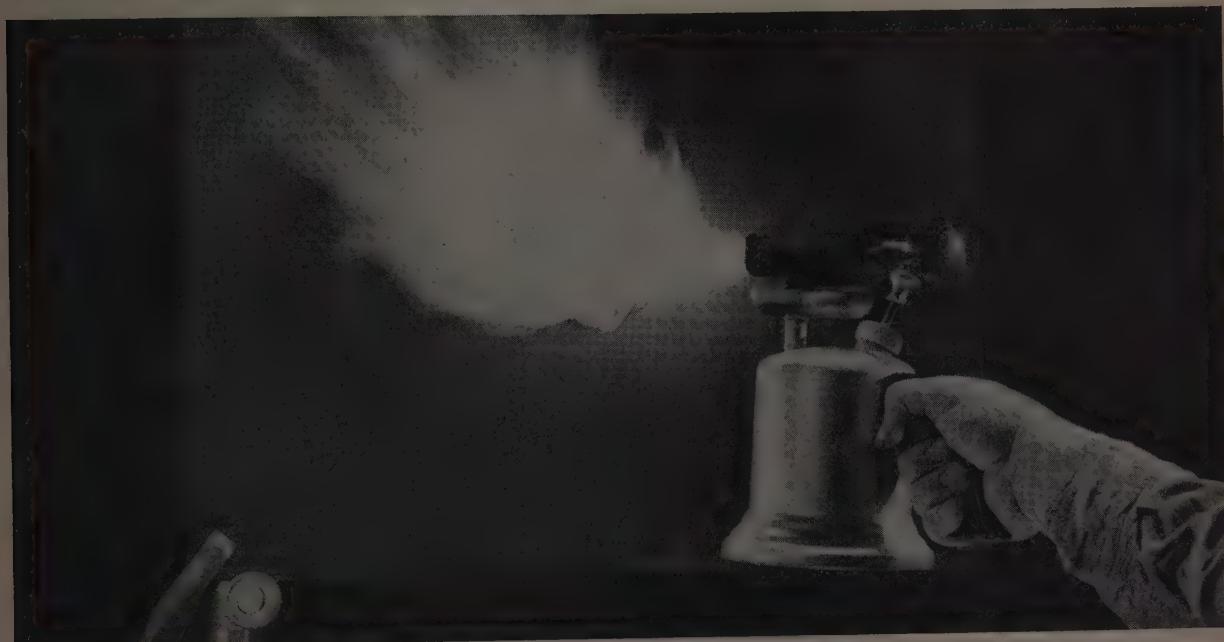
4501-C Ravenswood, Chicago 40, Ill.

Canada: Atlas Radio Ltd., Toronto

Write in No. 186 on Reader Service Card

SPACE/AERONAUTICS

Why the new interest in flame retardance of plastic laminates?



Sheet of Synthane to which blowtorch is being applied

While it is unlikely you will ever take up your blowtorch to sample the flame resistance of laminated plastics, this property emerges as a lively topic for discussion among engineers.

Admittedly its import is for the councils of those whose equipment is flame-exposed or is powered, amplified or controlled by vacuum tubes and upon which, clustered or confined, you could properly fry an egg.

Under the circumstances, it is appropriate to ask what laminated plastics (or Synthane, to name our choice) have to offer in the way of flame retardance, and how this property relates to the other, and more widely used, advantages of laminates.

Two Specific Flame Retardant Laminates

There are two grades of Synthane laminates specifically earmarked for flame retardance—Grades FR-1 and FR-2. Except for its flame retardance, Grade FR-1 closely resembles standard paper base phenolic Grade XX Synthane. Grade FR-2 is similar to Grade FR-1, but may be readily hot punched and would be used where flame retardance with emphasis on punchability was desired.

Many Grades of Synthane Self Extinguishing

Many standard grades of laminates—though they contain no flame retardant additives—are self extinguishing. That is, they do not support combustion when the flame is removed.

For example, the fabric and glass melamine grades are excellent for their self-extinguishing characteristics. The same is true of the asbestos grades. Why, then, special flame retarding grades? The answer is partly financial.

The flame retardant grades FR-1 and FR-2 offer good electrical and mechanical properties (similar to Grade XX) plus excellent flame retardance and at a moderate cost. When the electrical or mechanical requirements are severe it is they that may control the choice of laminate even though flame retardance is still necessary. And it just so happens that the cost of producing grades with superior electrical and mechanical properties tops the cost of producing flame-retardant Grades FR-1 and FR-2.

Comparison of Properties of Synthane Laminates with Relation to Flame Retardance

GRADES

Property	FR-1	FR-2	XX	C	L	C-M	L-M	G-5	G-8	A-M	AA-M
Flame Retardance	E	E	P	P	P	P	E	E	E	E	E
Heat Resistance	F	F	P	P	P	P	G	G	E	E	E
ARC Resistance	P	P	P	P	P	P	E	E	E	E	E
Mechanical Strength	F	F	F	G	G	G	G	E	G	G	G
Dimensional Stability	F	F	F	F	F	G	G	E	E	E	E
Mechanical Resistance	E	E	G	G	G	G	E	E	E	E	E
Dielectric Strength	E	E	G	F	F	F	F	E	F	F	F
Machinability	E	E	E	E	E	E	F	F	F	F	F
Cost	Low	Low	Low	Low	Mod	Mod	High	High	Mod	Low	High

E=Excellent, G=Good, F=Fair, P=Poor

Obviously there is more to this business of selecting an electrical insulation than flame retardance. In any spot where flame retardance is a factor it is prudent to consult with us, directly or through our representatives, to secure

for yourself the Synthane Grade which supplies *all* of the properties you need in combination and at a reasonable cost. Our aim is to help you obtain the most for your money so that you may find coming to us a profitable habit.

For further information about Synthane standard or flame retardant grades write Synthane Corporation, 55 River Road, Oaks, Pa.



Flame retardant test on Synthane for switch-gear application. Heat is supplied by coil encircling the sample. Temperatures up to 1600°-1800°F are measured with optical pyrometer.

SYNTHANE
CORPORATION, OAKS, PENNA.
Laminated Plastics for Industry
Sheets, Rods, Tubes, Fabricated Parts
Molded-laminated, Molded-macerated

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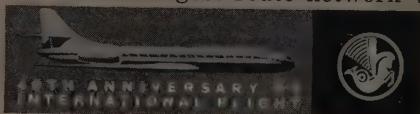
FRENCH AIRLINE LAUNCHES FIRST FAR EAST SERVICE!

CAPTAIN M. NOGUES COMPLETES
FIRST SCHEDULED FLIGHT
BETWEEN MARSEILLES, SAIGON!

Marseilles, France, February 15, 1931—Captain Maurice Noguès landed his trimotor Fokker aircraft at La Ciota Airfield today after completing the first scheduled round-trip flight between Marseilles and Saigon, Indo-China. Captain Noguès' exploit marked the culmination of five years of exploratory flights along the route. The service is expected to speed mail, cargo and passengers between Paris



FIRST IN INTERNATIONAL AIR TRAVEL! Since the very beginning of aviation history, men like Blériot, Bossoutrot and Noguès have led the way in international flight. Today Air France continues this tradition of leadership in air transport by offering the most non-stop flights both ways between New York and Paris and the fastest jet service in Europe and the Middle East. Next year Air France plans to cover the world's largest route network with one of the largest fleets of jet aircraft in the world.

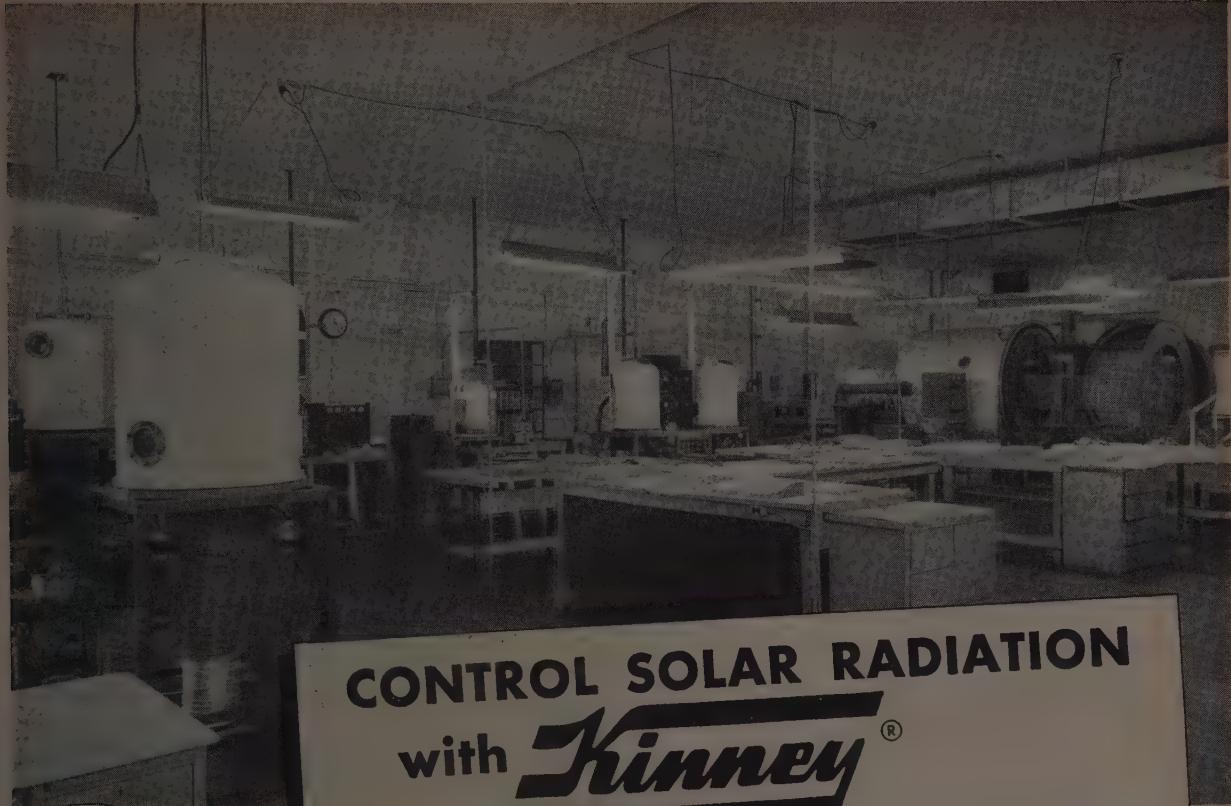


AIR FRANCE

WORLD'S LARGEST AIRLINE / WORLD'S FIRST INTERNATIONAL AIR SERVICE

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SPACE/AERONAUTICS



CONTROL SOLAR RADIATION with **Kinney**[®] PRECISION EVAPORATED FILMS

The answer to your problems with Solar Radiation may well be found in KINNEY High Vacuum Coatings. Have you explored the possibilities of controlling REFLECTION, TRANSMISSION, ABSORPTION and EMISSIVITY with KINNEY Precision Evaporated Films? Here are advanced techniques, backed by years of research and successful production of optical and electrical films applied to a broad range of surfaces and substances.

DO YOU SEEK PROTECTION OF INSTRUMENTS FROM SOLAR HEAT?

KINNEY offers Infra-red Reflecting Films designed to your specifications... can be deposited on Glass, Plastic or Metal... and many other materials.

DO YOU SEEK IMPROVED GUIDANCE CONTROL?

KINNEY Infra-red Low Reflection Films provide peak transmission of desired wave length on Glass, Quartz, Germanium, Silicon, Arsenic Trisulphide and many other materials.

DO YOU WISH TO CONTROL EMISSIVITY?

KINNEY provides precise deposition of films for Dark Mirrors and Beam Splitters as well as Absorbing Films.

DO YOU NEED THESE ELECTRICAL AIDS?

KINNEY R.F. Shielding Films... Anti-electrostatic Films... Transparent Conducting Films... Solderable Films on Glass, Phenolics, etc.

THESE DEVELOPMENT AND PRODUCTION FACILITIES ARE AVAILABLE TO YOU

FRONT AND BACK SURFACE MIRRORS - ANY METALS
LOW REFLECTION FILMS - ANY WAVE LENGTH
SEMI-TRANSPARENT FILMS - DICHROICS
BEAM SPLITTERS - R.F. SHIELDING
ANTI-ELECTROSTATIC FILMS

Write for information regarding your specific problem... no obligation.

VACUUM EQUIPMENT DIVISION THE NEW YORK AIR BRAKE COMPANY

1327E ADMIRAL WILSON BLVD. • CAMDEN • N. J.

Please send me information on Mirrors Low Reflection Films Infra-red Films Semi-Transparent Films Dichroics Beam Splitters R.F. Shielding Have engineer call.

Name _____

Company _____

Address _____

City _____ Zone _____ State _____

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NOISE problem?



solve it with **WILLSON**
SOUND BARRIER

Here is the completely effective, *sure answer* to most high-level noise problems associated with aircraft/missile ground operations. The 258 SOUND BARRIER developed by the Willson Research Center is scientifically designed with *fluid-filled cushions* to properly baffle harmful high-frequency noises even when accompanied by extreme vibration. Yet it lets the wearer hear spoken instructions and enjoy a new standard of hearing-protection comfort!

The SOUND BARRIER has been exhaustively tested as your assurance of the finest in personal noise protection.



FLUID-FILLED CUSHIONS ASSURE NOISEPROOF FIT

This exclusive SOUND BARRIER feature provides a comfortable, *contoured seal* around the ears... for far better noise attenuation than cushions of any other material. Unaffected by temperature and pressure extremes... tested at -35°F and at 40,000 feet simulated altitude. (Available with earphones, or microphone with earphones.)

TRIAL TEST OFFER

Call the nearest Willson distributor for a SOUND BARRIER trial test, or write us for his name.

WILLSON PRODUCTS DIVISION
RAY-O-VAC COMPANY

Reading, Pennsylvania

Write in No. 190 on Reader Service Card

DATA PREVIEW

TRANSFORMERS—A new 100-page variable transformer Bulletin P258G or wh want to know more about variable transformers. This comprehensive, easy-to-read, file-fitting guide gives product information, engineering data, outline drawings, connections, ratings, charts and illustrations on all standard 50/60 cycle powerstats plus some special use types, and is available from Superior Electric Co., Dept. S/A, Bristol, Conn.

Write in No. 371 on Reader Service Card

PHOTOGRAPHY—An eight-page brochure on the Kth 57 cine theodolite for ballistic and missile photography is available from Perkin-Elmer Corp., Dept. S/A, Norwalk, Conn. It describes the performance and specifications of the theodolite and its controls, and also discusses an available master station which allows synchronous operation of up to four cine theodolites.

Write in No. 372 on Reader Service Card
more on page 284

NEED ASSISTANCE IN OPTICAL ELECTRO-MECHANICAL INSTRUMENTATION...

DESIGN ENGINEERING...

PRECISION MANUFACTURE ?

LET WOLLENSAK OPTICAL COMPANY BE OF SERVICE TO YOU...

We are specialists in the development and manufacture of custom optical-mechanical devices... concentrating on products which require high engineering excellence and precision manufacture.

We have worked with many of America's largest corporations, such as GE, Philco, RCA, Haloid Xerox assisting them with sub-assemblies, optical-mechanical engineering and manufacture of units, in which we are extremely capable. Why not contact us on your next problem.

Call or write.

OPTO-MECHANICAL DIVISION

WOLLENSAK

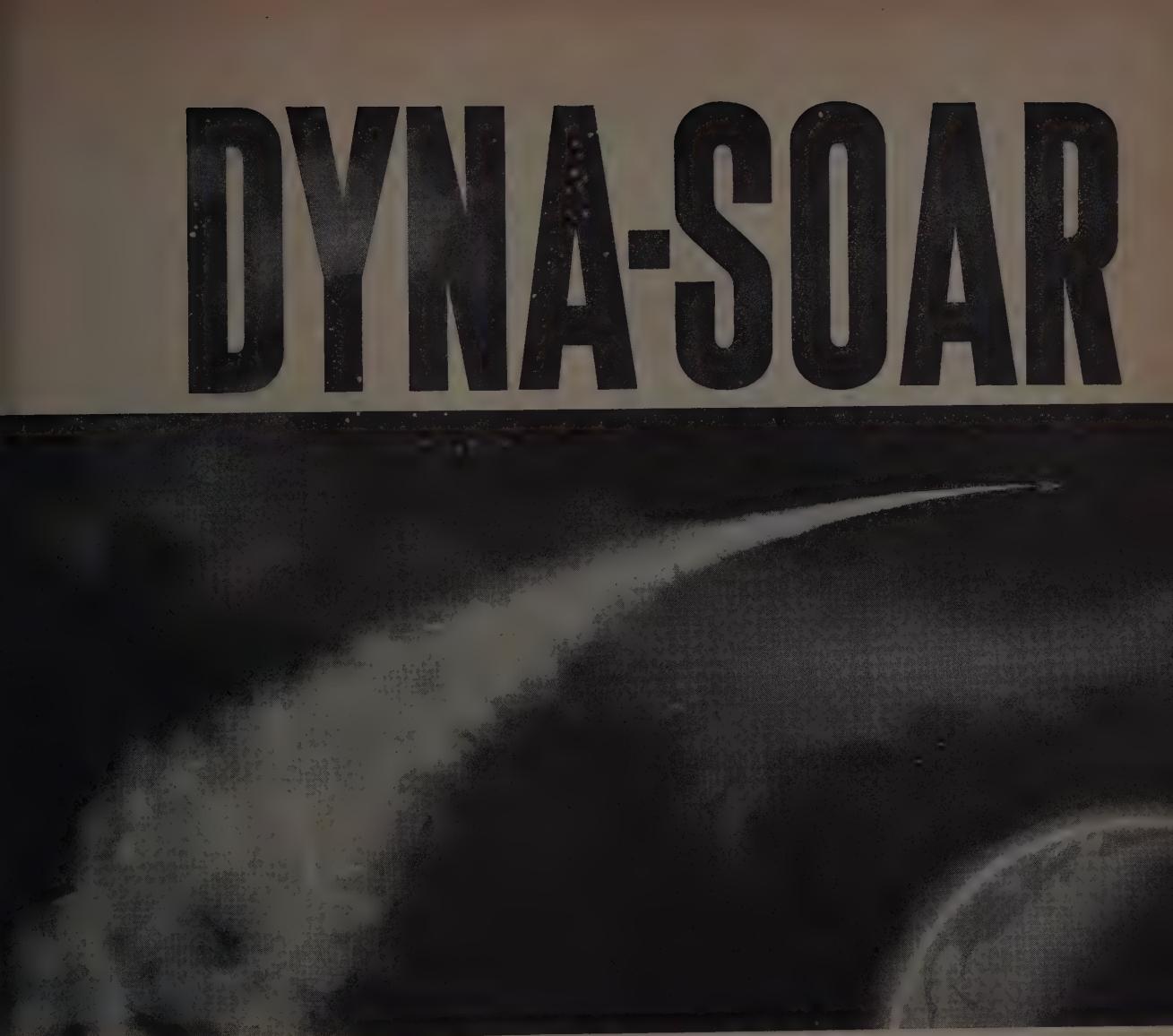
OPTICAL COMPANY, ROCHESTER 21, NEW YORK

Optical Specialists Since 1899

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SPACE/AERONAUTICS

DYNA-SOAR



Dyna-Soar (for dynamic soaring) is a joint project between the Air Force and the NASA, and is an attempt to solve the technical problems of manned flight in the sub-orbital regions. Advance knowledge on the project indicates how a boost-glide vehicle can operate from the outer fringes of the atmosphere where it can maneuver and be recovered undamaged. Studies show that by varying the original rocket boost,

and thus the velocity, and with the control available to the pilot, the Dyna-Soar aircraft can circumnavigate the earth, followed by a normal and controlled landing. Boeing Airplane Company, one of the competing companies for the development contract for the complete boost-glide system, has delegated to RCA the responsibility for the development of important electronic components of Dyna-Soar.



RADIO CORPORATION of AMERICA

DEFENSE ELECTRONIC PRODUCTS
CAMDEN, N. J.



Gevaert X-ray films are used to inspect wing structure of Convair B-58 "Hustler."

GEVAERT STRUCTURIX X-RAY FILMS

.....for proof of the product

Quality-conscious industries rely on Gevaert X-ray films to assure product perfection. These films probe deep to search out flaws, and emulsion and base characteristics combine to define and separate the most delicate tones.

Gevaert Structurix X-Ray Film Types—

D-2: A unique slow-speed film of incomparable quality. Gives highest detail and finest grain available in any film. Designed especially for rechecks and production inspection of thin or medium sections, and light metals.

D-4: A medium-speed fine grain film for inspecting medium thick or thick sections of light metals, and thin sections of heavy metals.

D-7: A high-speed film for medium to fairly thick light metals, thin and medium sections of heavy metals. Also for gamma radiography.

If you would like the details on all five Structurix Films, send for the free new booklet "Gevaert Industrial X-Ray Films."

GEVAERT

THE GEVAERT COMPANY OF AMERICA, INC.

321 West 54th Street, New York 19, N. Y.

*District Offices: Lincolnwood, Ill. (Chicago) • Los Angeles
Dallas • Denver • San Francisco*

Write in No. 192 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

METAL PROPERTIES — Melting points and densities of metals have been covered in two separate charts available from Metals & Fabrication Div., Fansteel Metallurgical Corp., Dept. S/A, North Chicago, Ill. Both Fahrenheit and Centigrade scales are used, and densities are grouped into heavy, medium and light classifications.

Write in No. 373 on Reader Service Card

PROCESS CONTROL—Punch card machine tool positioning and programming has been covered in Bulletin J 200 by The Jordan Co., Inc., Dept. S/A, 3235 W. Hampton Ave., Milwaukee 9, Wisc. The bulletin describes the Shaftrol positioning gearmotor, which is capable of providing resolution of one part in 1000 for each of its coarse and fine sensors.

Write in No. 374 on Reader Service Card

METAL FINISHING — Technical Bulletin No's 215 and 221 describe the plating and surface-treatment processes carried out at Metalectro Laboratory, Dept. S/A, 11423 Vanowen St., Unit 30, No. Hollywood, Calif. The general information bulletin covers the general field of industrial metal finishing, and also specialized plating procedure.

Write in No. 375 on Reader Service Card

ELECTRIC CONTACTS—An eight-page brochure covering engineering data and contact selection, materials, design and sizes of electric contacts has been issued by Contacts Inc., Dept. S/A, 1100 Silas Deane Highway, Wethersfield, Conn. "Electrical Contact" includes data on standard solid rivet types, button contacts, and composite contacts.

Write in No. 376 on Reader Service Card

OSCILLOGRAPH—A 12-page booklet, Bulletin 1585A on the Type 5-122 recording oscilloscope has been prepared by Consolidated Electrodynamics Corp., Dept. S/A, 300 N. Sierra Madre Villa, Pasadena, Calif. The flight-test instrument is designed for environmental extremes, features a crash-resistant magazine, and provides 26 active and two reference traces.

Write in No. 486 on Reader Service Card

FASTENERS — Literature is available from Waldes Kohinoor, Inc., Dept. S/A, Long Island City, N. Y. A three-page illustrated brochure gives complete engineering specifications data for the Waldes QAF quick-action stressed panel fastener, while the nine-page illustrated bulletin is devoted to the results of a series of qualifications test conducted in accordance with specifications of NAS 547, Revision No. 1, dated Oct. 15, 1956.

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Write in No. 193 Reader Service Card

LINDE'S NEW PLASMARC TORCH SERVICE

Brings Industry Production Parts From Refractory Metals

No other method of fabricating refractory metals can match this. . . . The high melting points of tungsten, tantalum, and molybdenum are no longer a problem. For LINDE's new PLASMARC Torch, working in the temperature range between 15,000 and 30,000 degrees K., can coat parts or form shapes of virtually any size or complexity. It's an entirely new way to make such articles as rocket nozzles, crucibles, components for electronic and X-ray use, and parts for atomic energy equipment!

The quality of these pieces is uniformly high. Tolerances can be held to $\pm .002$ in. or better. The metal

loses none of its purity and superior density is achieved.

With the PLASMARC Torch, LINDE is equipped to supply you with parts made of, or coated with, refractory metals; or made of a variety of metals combined with non-metals or reinforced plastics. LINDE will also provide a wind-tunnel materials testing service based on this device. For information on this extension of LINDE's well-known Flame-Plating service, write Dept. AW-13, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N.Y. In Canada: Linde Company, Division of Union Carbide Canada Limited.



The PLASMARC Torch employs a non-transferred electric arc to generate such high temperatures that powder or wire fed into the chamber is literally melted. Inert gases flowing continuously carry the metal particles in a plastic state and deposit them on the work piece at near sonic speeds. Jets of CO_2 cool the particles instantly to form heat- and erosion-resistant material. Coatings—even on graphite—have an excellent bond. Shapes are built up on machined mandrels, which are then etched away to leave parts such as those shown above.

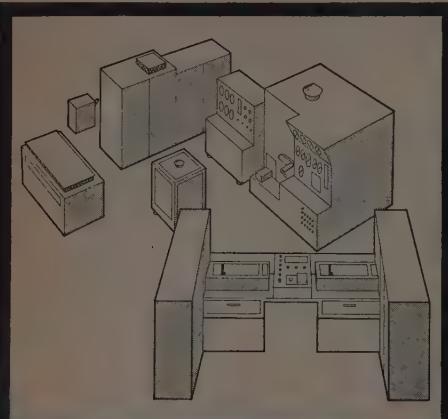
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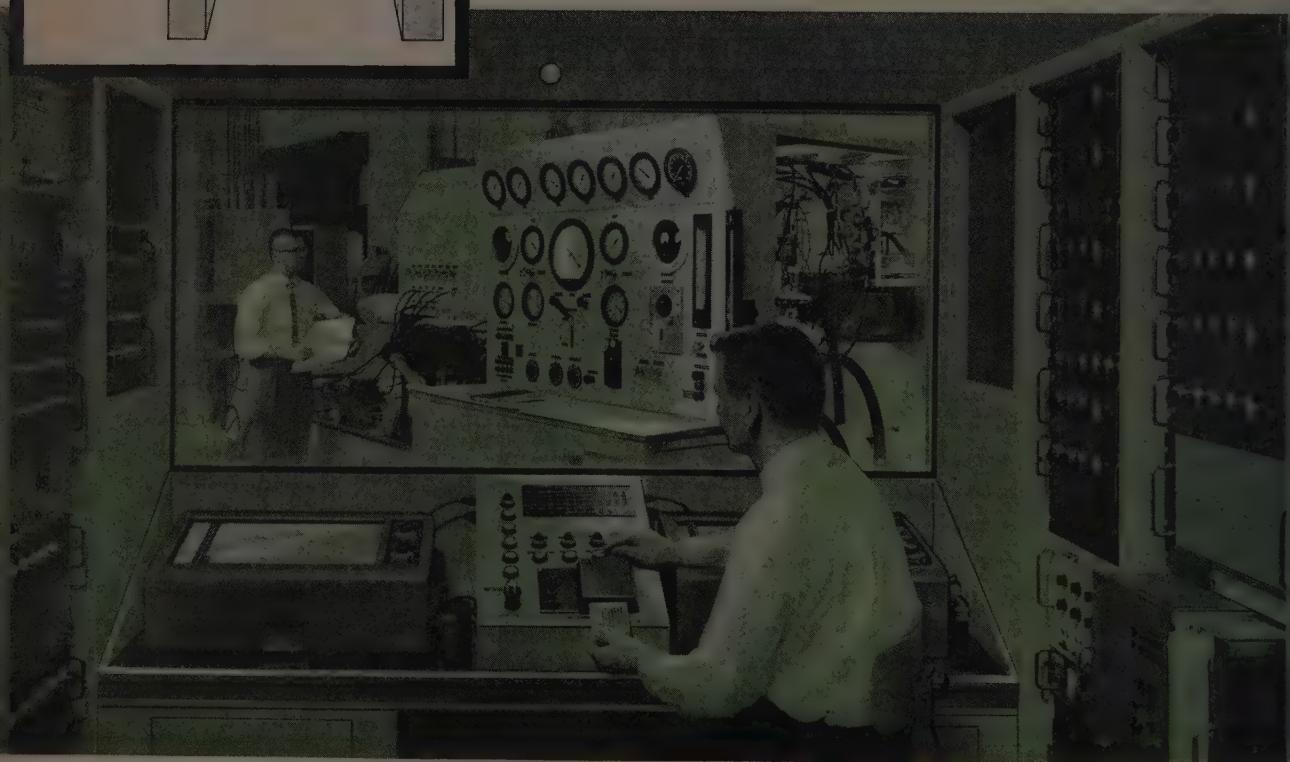


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Nankervis offers you two decades of test equipment experience, with top-flight testing engineers to serve you in the country's most modern test equipment facility.

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readers' round table

Technical talent management for R&D

by Irven Travis

Vice President—Research & Engineering,
Burroughs Corp.

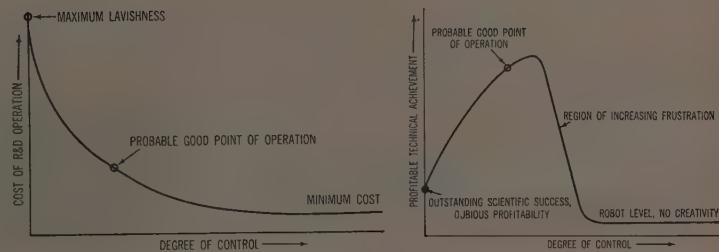
TO MANAGE technical talent, one must know something of the technical man to be managed. He is a sensitive individual whose greatest reward is a sense of accomplishment.

He wants to know what is expected of him, but he does not want to be told how to do it. He is intolerant of petty annoyances: rigid control of his time and delays in approval of purchase requisitions irk him exceedingly. He will not cheerfully accept counsel from a superior unless that superior has his complete technical respect.

Each technical man has a certain level of creative talent. If he is creative, he does not think along conventional lines. If he does not think along conventional lines in his specialty, he may be expected not to think along conventional lines in other matters. The more creative he is, the more he thinks he should do his own planning, and the less constraint he is willing to accept from others.

It is in this question of degree of constraint that we approach one of the most critical aspects of management of technical talent. If an individual is keenly interested and highly talented in a certain narrow technical field, you can be sure that whatever end objective is set for him it will be done by his pet technique.

Contributions to this department may be on any subject, technical or nontechnical, about which readers would like to air their views. Names and professional affiliations will be withheld on request.



COST and profitable technical output as functions of control.

If his field is optics, and you ask him to develop an automatic computer, it will not be of the old traditional mechanical type, not the newer exciting electronic type—it will be optical. It is in the process of *matching the man to the task* that success or failure will be achieved.

Don't try to change a creative person!

You should not try to change a creative individual. The likelihood of success is negligible, and if you were to change a creative individual, you could do so only at the expense of destroying his creative talent.

In any R&D program there must be a spectrum of work ranging from very basic additions to human knowledge to the development of a product prototype. At the most fundamental end, objectives are understood only in the most general terms. Also, errors in obtaining these objectives are tolerable. A basic research result, not quite on target, is still likely to have value.

At the other end of the scale stands the development of a product prototype. Unless the prototype

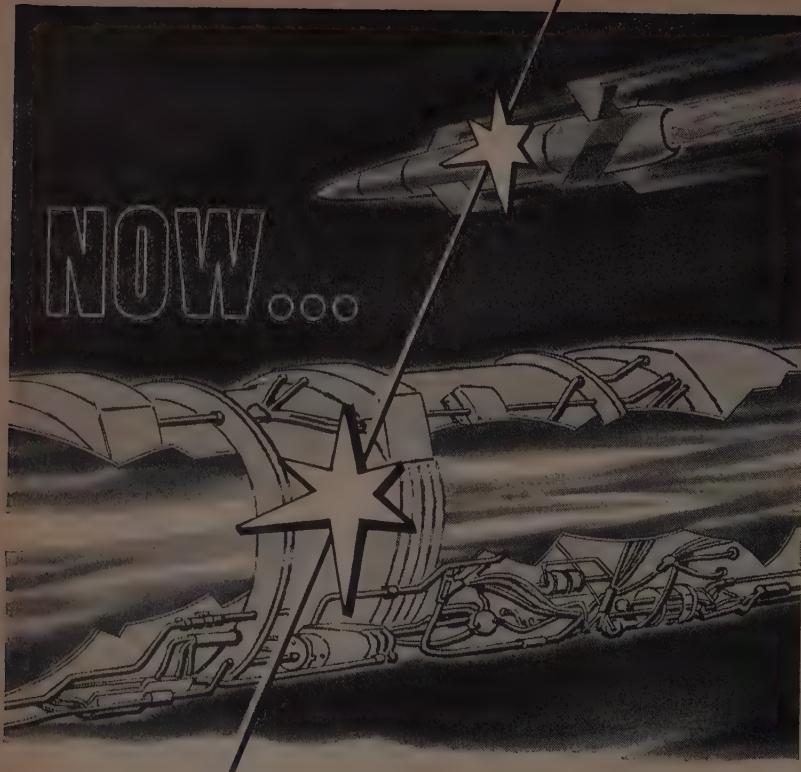
is manufacturable and salable at a profit, the money spent on its development is almost a total loss.

It is clear that the rigidity of constraint in the first case is minimal and that the opportunity for creativity is very great. In the case of the product prototype, the objective is quite accurately defined. Constraints to conform to the definition must be rigid, and little opportunity for creative thinking exists.

Personnel must be assigned in this creativity spectrum in accordance with their natural inclinations. There must be a close match between the requirement for constraint and willingness to be constrained. The man who wants to develop and design for a specifically defined objective, using proven principles but is assigned to a job loosely defined and requiring a great deal of original thinking will be ineffective. He will try, but lacking the originality that's needed he is unlikely to produce well enough to justify retaining him in that assignment.

If a highly creative scientist is given a job hemmed in by technical decisions already made for him, he will not even try. He will seek

more on next page



a silicone resin sleeving so flexible you can get it in spools or coils!

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- **COLOR CODED** — available in 12 brilliant, non-fading colors.
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assignment, and if he cannot get reassignment, he will quit.

In my opinion, there is no greater single source of frustration and therefore ineffective use of technical personnel than a mismatch of the creativity of the individual and the creative opportunities of his job assignment. *A good match must be made between the talents and inclinations of the individual and the objective which his job is to attain.*

Any R&D program has two types of control

In an R&D program, there are actually two types of control. I believe that in most managements there is generally less appreciation of the need for technical control and more consciousness of the need for financial control. Technical control is more subtle, very hard to measure, and is much more of an art than financial control.

Efficiency, in the scientific sense, is defined as the ratio of output to input. The efficiency of an industrial R&D program is profitable technical achievement per dollar spent. From the standpoint of corporate management, profitable technical achievement is the output. Dollars spent is the input.

A simple approach to maximizing efficiency would be to work independently upon numerator and denominator of the efficiency fraction—to try by any means to increase profitable technical achievement and, through suitable financial controls, to reduce costs. This approach would ignore the fact that both input and output are functions of control.

Control, as it affects cost, is both functional and financial control, but primarily financial. Control, as it affects profitable technical achievement, is both functional and financial, but more functional.

The curve of cost vs control starts at a high value, the luxurious operation which might exist if there were no controls at all, and decreases, becoming asymptotic to an irreducible minimum below which no further control would be effective.

The profitable technical achievement curve starts at a low value (not zero, because with no control whatever, intelligent people would do something useful), and rises

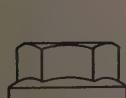
more on page 290

5 Ways to Save Fastener Weight

New FN Featherweight locknut series
combines minimum mass, outstanding performance



SPS FN-12 Series
Featherweight Hex Locknut



Up to 72% lighter than commonly used sheet metal or AN Series nuts. Tolerance on squareness of bearing surface to threads is 50% less than required by specification, providing reduction in stress concentration. Vibration resistance exceeds MIL-N-25027 requirements by 50%.

Characteristics

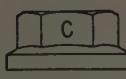
Sizes—#4 through $\frac{1}{2}$
Tensile strength—160,000 psi
on 180,000 psi tensile bolt
Temperature—550°F max.

Material—Alloy steel
Plating—Cadmium

SPS Bulletin No. 2426



SPS FN-812 Series
Featherweight Hex Locknut



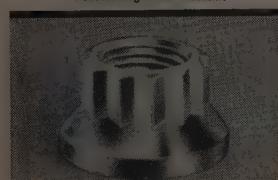
Designed for 800°F service. Corrosion and oxidation resistant; low magnetic permeability. Up to 60% lighter than conventional NAS 679 counterparts. Also less costly because made of austenitic stainless instead of A-286 super alloy.

Characteristics

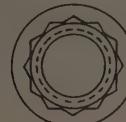
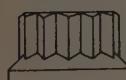
Sizes—#4 through $\frac{1}{2}$
Tensile strength—160,000 psi
on 180,000 psi tensile bolt
Temperature—800°F max.

Material—Austenitic stainless
Plating—Silver

SPS Bulletin No. 2521



SPS FN-22 Series Featherweight
12-Point External Wrenching Locknut



Static strength capable of breaking a 220,000 psi tensile bolt. Lightest locknut of this strength available in sizes #10 through $1\frac{1}{2}$. Exceptionally close tolerance on bearing face squareness gives up to 30% longer bolt fatigue life.

Characteristics

Sizes—#10 through $1\frac{1}{2}$
Tensile strength—220,000 psi
Temperature—550°F max.

Material—Alloy steel
Plating—Cadmium

SPS Bulletin No. 2487



SPS FN-920 Series Featherweight
12-Point External Wrenching Locknut



900°F locknut designed for use with high-strength engine bolts having 0.003 in. reduced pitch diameter. Close control of squareness between bearing face and threads makes these the only standard nuts for their temperature meeting squareness requirements of MIL-N-7873.

Characteristics

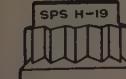
Sizes—#10 through $\frac{1}{2}$
Tensile strength—200,000 psi
Temperature—900°F max.

Material—AMS 6304
Plating—Nickel-cadmium, Silver

SPS Bulletin No. 2504



SPS FN-1216 Series Featherweight
12-Point External Wrenching Locknut



Offers 160,000 psi tensile at room temperature; 140,000 at 1200°F. Reduced stress concentrations achieved by maintaining 0.003 in. bearing face squareness. Simulated service tests document high lock retention during repeated 100 hr. exposure to 1200°F while stressed to 90,000 psi.

Characteristics

Sizes—#10 through $\frac{1}{2}$
Tensile strength—160,000 psi
Temperature—1200°F max.

Material—SPS-M-118 (A-286)
Plating—Silver

SPS Bulletin No. 2468

Extensive laboratory tests have been conducted on each design of SPS Featherweight series locknuts to insure their meeting or exceeding specification or application requirements. For bulletins or samples, write SPS—manufacturer of precision threaded fasteners and allied products in many metals, including titanium.

AIRCRAFT/MISSILE Division

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⊕ Expanded Research programs to meet the most complex technological requirements of the Space Age are only one of the far-reaching objectives of the new multi-million-dollar Lockheed Research Center, near Los Angeles. Destined to become one of the nation's major research installations, its programs are broad in scope and designed to investigate new frontiers of space flight.

⊕ A primary consideration in planning the new Research Center was to provide environment for scientific freedom and ideal research conditions—using the most advanced equipment available. This modern, integrated research facility will touch almost every aspect of aviation and transportation—leading toward exploration into completely new or relatively undeveloped fields of science and industry.

⊕ On completion, most of Lockheed's California Division's research facilities will be located in this single area. The Center will provide complete research facilities in all fields related to both atmospheric and space flight—including propulsion, physiology, aerodynamics and space dynamics; advanced electronics in microwave propagation and infrared; acoustics; mechanical and chemical engineering and plasma/magnetohydrodynamics; thermal electricity; optics; data communications; test and servo-mechanisms.

⊕ The first phase of the advanced research building program has already begun—with initial construction of a \$5,000,000 supersonic wind tunnel and high-altitude environmental test facilities.

⊕ Scientists and engineers of high caliber are invited to take advantage of outstanding career opportunities in this new Lockheed Research Center. Openings now exist for thoroughly qualified personnel in: Electronics; aero and thermo dynamics; propulsion; servo-mechanisms; materials and processes; structures and stress; operations research; research in optics, infrared, acoustics, magnetohydrodynamics, instrumentation, mechanics and hydraulics; mathematics and in all phases of design.

⊕ Write today to: Mr. E. W. Des Lauriers, Manager Professional Placement Staff, Dept. 1905, 1708 Empire Avenue, Burbank, California.

gradually, as control is increased, to a critical peak value. Control beyond this point causes the output to decline very sharply to a small, constant value.

I think it is evident that a certain degree of control is necessary, but that over-control is suicidal. On the curves is a point well down toward diminishing improvements in cost and safely away from the danger point on profitable technical achievement. This point might indicate an optimum degree of control.

If too much control is to be avoided, then the need to control must be eliminated. This means good understanding at all operating levels of the broad goals and objectives. This understanding must start with top management.

The beginning of an understanding by the rank and file of R&D people of their own objectives lies in sound R&D planning at the highest level, and the communication of these plans in proper terms to all levels of organization. Top level planning must result in an R&D program which is oriented to the needs of the corporation as opposed to the curiosity of the investigator.

If an R&D program is to be oriented toward the profit needs of a corporation, we first must examine the corporation itself to find what these needs may be. Any corporation has an operating complex through which it earns profits. It may make and sell a line of products in a comparatively narrow field. It may operate in a broad area in which the common denominator is the underlying technology, such as the office equipment industry, which sells data processing equipment.

The corporate complex ordinarily has evolved from a much simpler operation, sometimes by plan, often by chance. However the corporate earning complex may have come into being, it has attributes that can be studied from the viewpoint of R&D needs. It has strengths that are available to exploit research results, it has weaknesses that R&D may be able to overcome. The strengths and weaknesses must be carefully evaluated—as they exist now and as they may be expected to exist in the future.

There are many considerations that have to do with corporate

more on page 293

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and surface roughness inspection were used to achieve the finish required by the customer.

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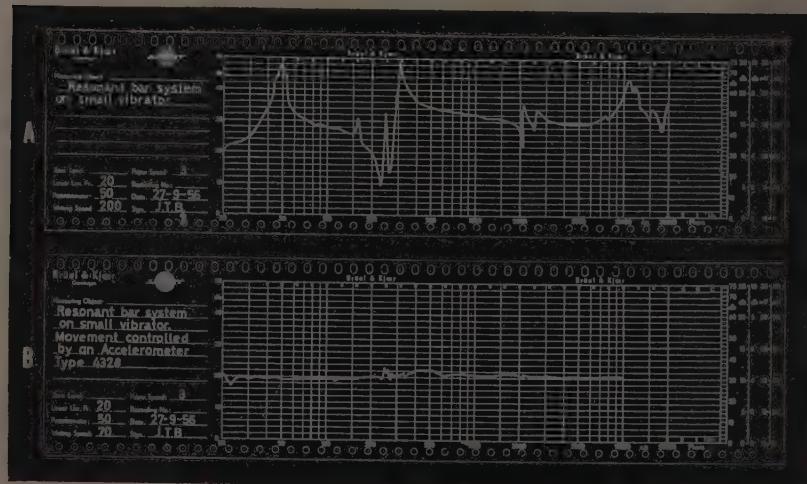
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SPACE/AERONAUTICS

policy with respect to R&D. Top management must apply them and many others to formulate broad objectives for an R&D program. After management has determined policy and objectives in the large, it is then the responsibility of technical management to translate these broad terms into a technical program. The end result of this two-phase R&D plan must be a technical content that matches the profit needs and the ability to exploit of the corporation.

When the technical program has been spelled out in detail by top technical management and is passed on to lower levels, the "why" must go with it. Communication to all levels of the total corporate picture is necessary to allow creative thinking at all levels. Never talk down to an R&D man. Never lose a chance to broaden his perspective about the way in which his efforts may be translated into company profits—this year, next year, or in the years to come.

He must understand management objectives in the broadest sense, and must understand why he is working on today's tasks. He must understand how his own creative modification of his own tasks can better align his results with the profits needs of the company. He must understand how his results, together, with the results of his colleagues, would be exploited by the company, and he should have a good idea of when and by whom.

With this type of understanding on the part of the individual, the need for constraints by management tends to fall away. I might sum up by saying that if research management is successful in assigning the right men to the right jobs and providing them with perspective regarding corporate aspirations, the only way it can mismanage is to manage too much.

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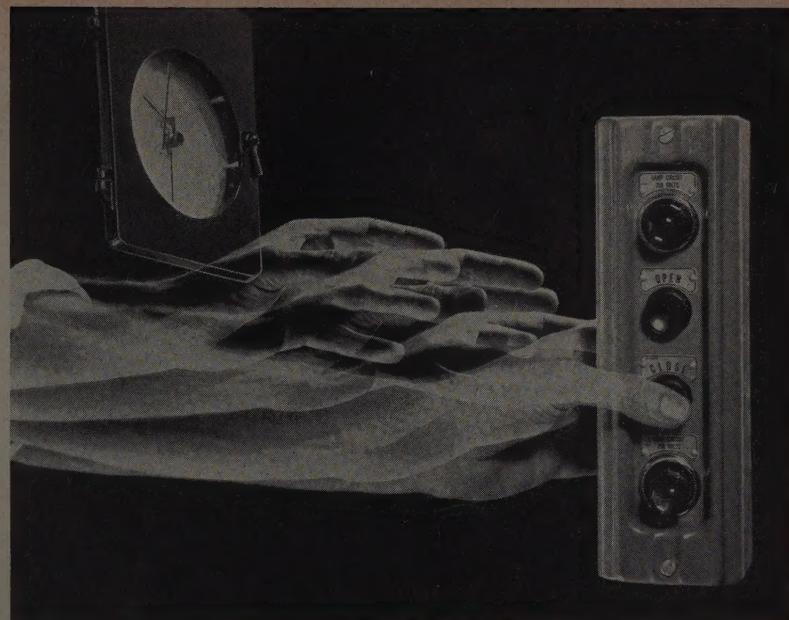


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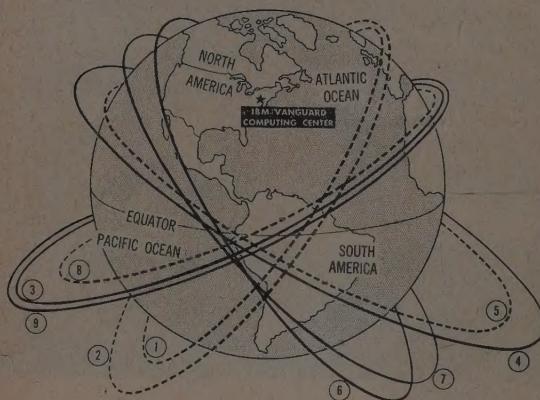
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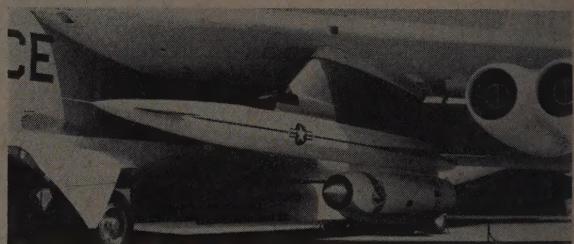


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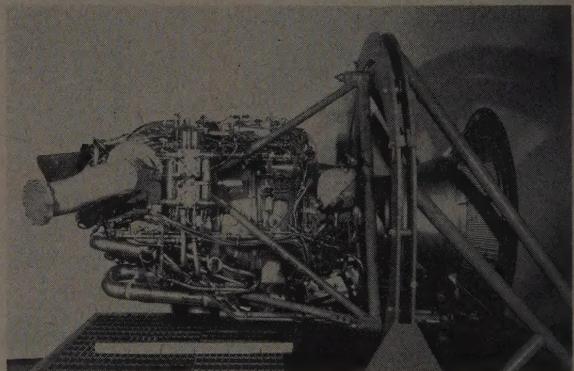


BRIEF RECAP of satellite orbits, maximum and minimum heights, and launch and fall dates (as of April 1) seems to be in order now that ten satellites have orbited: (1) Sputnik I—588 to 142 miles, Oct. 4, '57, to Jan. 4, '58; (2) Sputnik II—1038 to 140 miles, Nov. 3, '57, to Apr. 13, '58; (3) Explorer I—1537 to 224 miles, launched Jan. 31, '58; (4) Vanguard I—2453 to 409 miles, launched March 17, '58; (5) Explorer III—1741 to 118 miles, March 26, '58, to June 27, '58; (6) Sputnik III—1168 to 130 miles, launched May 15, '58; (7) Explorer IV—1380 to 157 miles, launched July 26, '57; (8) Atlas—625 to 118 miles, Dec. 18, '58, to Jan 21, '59; (9) Vanguard III—2050 to 335 miles, launched Feb. 17, '59.

SIKORSKY'S AMPHIBIOUS HSS-2, which made its maiden flight recently, is the Navy's first 'copter that can both seek out and destroy submarines. Much of its versatility it owes to its boat hull and its two GET58-6 turboshaft engines (each rated at about 1050 shp). Detail specs on the HSS-2 are still classified, but Sikorsky has revealed that its design is "in the weight class of a medium transport helicopter."

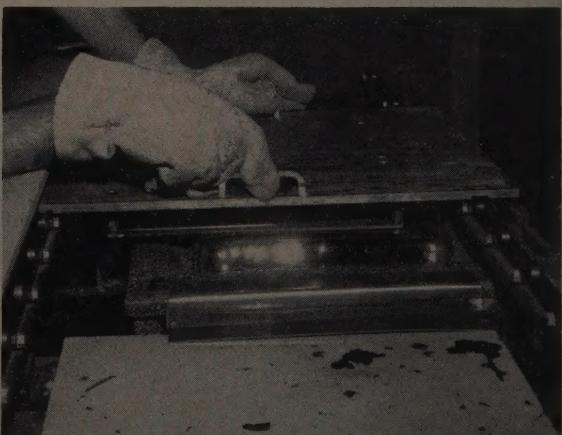


TRAINING and test model of North American GAM-77 Hound Dog has the same aerodynamic characteristics as the operational version of the air-to-ground missile.



FIRST SHOTS of Thiokol rocket engine for X-15 were released. Thrust is reported as 50,000 lb, which will give the manned research vehicle a 4000-mph speed.

FLOW SOLDERING machine for printed-circuit wiring boards eliminates cold joints and icicles, report engineers at new Phoenix, Ariz., plant of GE's Electric Computer Dept. In this high speed setup, a conveyor belt passes the boards over a dross-free, moving stream of molten solder.





SERGEANT

This missile system with nuclear capability is on the way to becoming a standard Army weapon. To be produced by Sperry-Rand, it is scheduled ultimately to replace the CORPORAL artillery missile system. The Jet Propulsion Laboratory-developed SERGEANT is invulnerable to any known enemy electronic counter-measures. And, thanks to a simplified Thiokol solid propellant rocket motor, the missile is extremely mobile — can be transported on military vehicles.

When SERGEANT becomes operational, the Army will possess one of the most maneuverable and accurate artillery weapons in its history.

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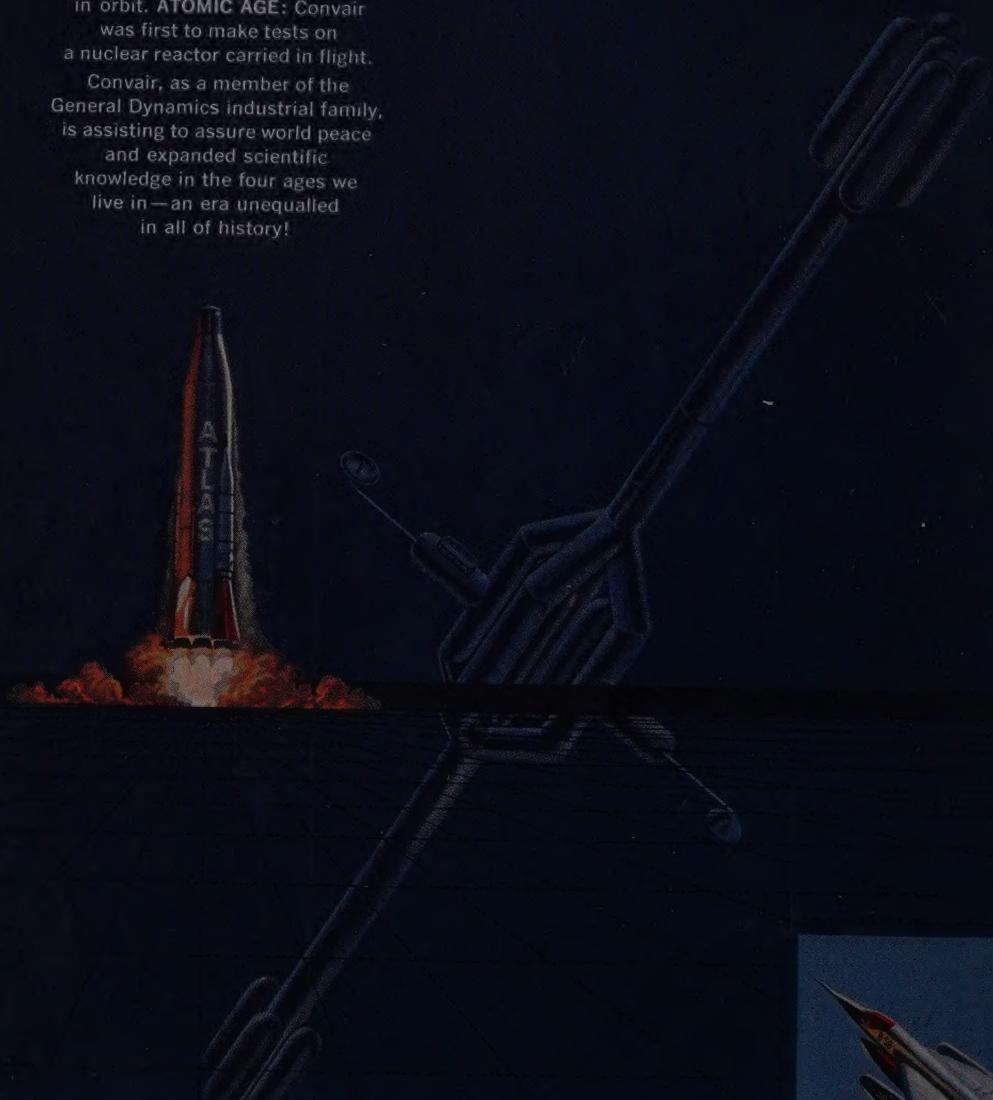
JET AGE • MISSILE AGE

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Atlas, our first Intercontinental Ballistic Missile. **SPACE AGE:** The world's first ICBM to be placed in orbit. **ATOMIC AGE:** Convair was first to make tests on a nuclear reactor carried in flight.

Convair, as a member of the General Dynamics industrial family, is assisting to assure world peace and expanded scientific knowledge in the four ages we live in—an era unequalled in all of history!



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